GULICK HYGIENE SERIES

THE BODY AT WORK

BY FRANCES GULICK JEWETT

Jack Dudeck
Grade 7

PORTLAND HIGH SCHOOL
PORTLAND MICHIGAN

THE GULICK HYGIENE SERIES

EDITED BY

LUTHER HALSEY GULICK, M.D.

THE GULICK HYGIENE SERIES

FIVE-BOOK SERIES

Book I. Good Health

Book II. Emergencies

Book III. Town and City

Book IV. The Body at Work

Book V. Control of Body and Mind

TWO-BOOK SERIES

Health and Safety

Physiology, Hygiene, and Sanitation

The Body and its Defenses

THE GULICK HYGIENE SERIES

Book Four

THE BODY AT WORK

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EDITOR'S NOTE

The primary object which has been sought in the preparation of this series of text-books on physiology and hygiene is the establishment of those hygienic habits which are basal to personal wholesomeness and efficiency. It is recognized that mere knowledge of an intellectual character is ineffective. We all know much better than we do. Only that knowledge is effective which is related to doing, — knowledge which we actually put into practice. The effect of knowledge upon action is an important, even if not the ultimate, criterion of its value. It is relatively useless to teach children about the body, unless the teaching is done in such a way as to lead them to desire to form their lives accordingly.

Habits are established not merely or mainly as the result of intellectual conceptions. Our daily habits are to a large extent a social inheritance from the customs of those among whom we grow up. This is true regarding the forms of our speech, the character of our clothing, habits of social intercourse, and the like, and it is not less true in the forming of hygienic habits.

The main object, then, in this series is to introduce that atmosphere, both of intellectual comprehension and

social custom, which shall result in the unconscious as well as the conscious development of the individual in these directions. An attempt is made to accomplish this through the different volumes of this series, though the method pursued differs somewhat with each volume.

(1) During the first three years of school life, in which the instruction is entirely oral, the most important aspects of personal hygiene are those which are taught not as theoretical lessons but as personal experiences. Cleanliness of hands and face, and of clothing and the room, freshness of the air, temperature, — these are taught not so much by formal lessons as by the teacher insisting that the pupils be clean, that their clothing be repaired and in order, that the room be clean, comfortable, well ventilated, etc. These matters should, of course, be called to the attention of the pupils as well as carried out in practice. The personal cleanliness and neatness of dress of the teacher are, of course, predominant factors in this whole matter.

(2) The volume entitled *Good Health* was written for the fourth grade. In this a general view is taken of the subject. Scarcely any anatomy and relatively little physiology are given, the main contents of the book consisting of concrete and interesting facts relating to pure air, tobacco, cleanliness, sleeping, eyesight, alcohol, hearing, finger nails, hair, care of the nose and teeth, and eating.

(3) The second volume in the series, *Emergencies*, approaches the subject of the formation of habits from the standpoint of the emergencies which come to children. Many of the same subjects are treated here that are discussed in the other volumes of the series, but from this special standpoint. The skin is discussed, not from the standpoint of general health or cleanliness, but from that of blisters and burns. The habits that it is desirable for children to form with reference to conduct during emergencies form the subject-matter of the year. It includes many of the topics that are ordinarily discussed under the subject of physiology and hygiene, but they are presented from this special point of view, — a point of view that is new to the child.

(4) The volume *Town and City*, which is prepared for the sixth year of school life, presents the subject of hygiene from the standpoint of the community, and habits of action which have a social bearing are discussed, — the results of overcrowding, clean streets, garbage, ashes and refuse, parks, playground, public baths, water supply, preventable diseases, food inspection, epidemics, vaccination, tuberculosis, city health and alcohol, microbes and disease. These are all topics in which individual action is involved. In all of them the relation and special emphasis are with reference to the state. The book is thus made an agency for the formation of habits having a community bearing.

(5) The fourth volume, *The Body at Work*, which is intended for the seventh grade, covers somewhat in detail the subjects ordinarily covered in the standard physiologies, but the emphasis is laid on the training of the body for efficiency. Thus much is said concerning the importance of good posture and how to secure it; how one trains the muscles of the body that they may be efficient, enduring, and strong; the nature and characteristics of useful exercise; how digestion is most efficiently carried on. The whole point of view concerns the training of the individual to most efficient bodily conduct. It relates particularly to the large physiological functions of digestion, circulation, nutrition, and respiration.

(6) The closing volume of the series relates directly to the establishment of habits themselves. The title of the book is *Control of Body and Mind.* In this book is discussed with some detail how habits are formed, not so much as a theory, but as an experience; how habits are broken, fatigue, the wholesome development of the brain and the spinal cord, the freedom which well-ordered habits give to the person who has them, the nerve endings and their care, etc. The whole purpose of the book is to give the individual that information which is related to the establishment of wholesome habits, particularly wholesome habits which shall be effective in the control of conduct.

Thus, while the direct object of this series concerns itself with conduct, particularly conduct with reference to health and efficiency, it covers all of the ground usually covered by discussions on physiology and hygiene. Because of the different points of view which are brought out during the different years. the range of facts presented is far greater than has ever before been presented to children.

LUTHER HALSEY GULICK

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INTRODUCTION

In the following pages emphasis is laid on function rather than on structure, on bodily health rather than on the mere mechanical operation of bone, muscle, gland, and tissue. So much of structure is, however, included as is necessary to show that we are personally responsible for the kind of service which we receive from the organs of the body; and that we are equally responsible for the habits of bone and muscle which determine the physical representation of ourselves to others.

Attention is drawn to right and wrong habits of sitting, of standing, and of walking; to the relation of the school desk to spinal curvature; to laws of growth, through the knowledge of which correct habits of posture may be secured; to the value of physical exercise as an aid to general health; to the development of muscular vigor and to the renewal of tissue through food and exercise.

By natural transition the work of the muscles leads to a study of the source of their energy,— the blood. Simple tests easily applied, acquaint the reader with the cause of rapid and slow heart beat, with methods of training the heart to increased power, with reasons

why an untrained heart should not be overtaxed, with the work of the lymphatics and the nature of the exchanges made between lymph and plasma. The insidious effects of alcohol on the heart and on the entire circulatory system is emphasized.

Certain conditions of breathlessness are discussed, and reasons are given for the statement that a man runs as much with his heart and with his lungs as with his legs. In natural sequence, this explanation involves not merely the structure and the function of the lungs but also a study of the exchange of gases both in the tissues and in the air sacs.

The notable experiments of Professor Chittenden with United States soldiers in New Haven, and of Dr. Cannon with cats in the Harvard Medical School, necessarily add a touch of picturesque reality to the otherwise prosaic subject of digestion. At the same time these experiments serve to illustrate the action of digestive juices on food, the effects of rapid eating on the nourishment of the body, the movement of the walls of the stomach during digestion, and the effect of fatigue, of unhappiness, of worry, anger, and anxiety on the normal progress of digestion.

Through this introduction to the subject prominence is given to the change of food from solid to liquid form, and to its absorption by the villi; also to the food requirements of the body under differing conditions of age and

activity; to the value of bulk in the food supply; to the functions of the liver and of the kidneys, and to the influence of alcohol in undermining their power for work; to the relation of sweat glands to bodily heat, and to the interdependence of work, heat, and fuel in the operations of the body.

These and other related topics have been brought to the notice of the students of this volume with the hope of imparting such enthusiasm for personal health and such clear notions of how to secure it, that the bodies of growing children may be strengthened as well as straightened, that lives may thereby be lengthened, and that through increased physical well-being the sum of human happiness may itself be increased.

Not merely is it the purpose of this series to teach scientific facts, but also, and especially, so to arrange and present these facts that from page to page they shall hold the reader's close attention and inspire personal loyalty to the laws of health. To further this purpose side headings have intentionally been omitted, so that each chapter may make its first appeal to the reader as a unified whole rather than as a series of disjointed fragments. While the disadvantages of side headings in interrupting the continuity of thought have been avoided, all their advantages are secured through the questions at the end of the volume, which, in a better form, answer the same purpose.

In so far as possible, the instruction of this text-book is everywhere reënforced by illustrations. Some of these are from photographs supplied by the author, others are copies of such as are already in wide use, while still others have been secured through the courtesy of the authors and publishers of notable investigations. Special mention should be made of indebtedness to the *American Journal of Physiology* for illustrations used by Dr. Cannon in his article on "The Movements of the Stomach studied by Means of the Röntgen Rays" (1898), and to Professor Chittenden for photographs of the soldiers with whom he carried on his food experiments.

Other valuable illustrations have been reproduced from *Practical Hygiene* by Alice Ravenhill, from *The Human Mechanism* by Theodore Hough and W. T. Sedgwick, from *Alcohol and the Human Body* by Sir Victor Horsley and Mary D. Sturge, and from *Unser Körper* by F. A. Schmidt. To each of these and to many other important works this little book is indebted not merely for illustrations but also for valuable facts which have been used in the preparation of its subject-matter.

F. G. J.

THE BODY AT WORK

CHAPTER I

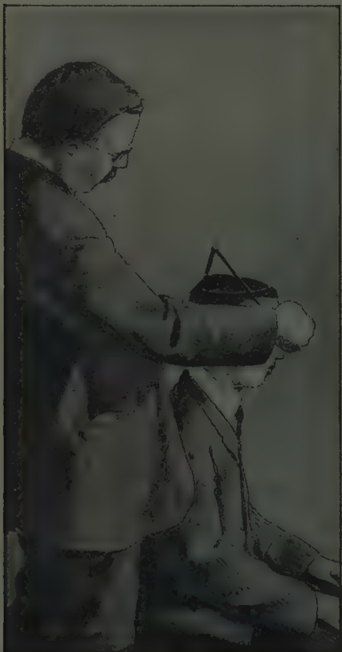
BONE AND MUSCLE RECORDS

Many cases are on record where a man has tried to hide his face when he thought his photograph was to be taken. He has seemed to understand that the photograph might betray him some day and lead to his being arrested again.

But some of our largest cities have adopted a new and surer way of keeping a reminder of their captured men. They measure each man carefully in different directions, — height in standing and in sitting, distance from the outstretched finger tip of one hand to the outstretched finger tip of the other, length and width of head and face and right ear, length of left foot, of left middle finger, and of left forearm. Scars are noticed and recorded; also the color of the hair and eyes, the shape of the nose, the number of teeth, etc.

In addition, the photograph is taken. And, queer though it may seem, the photograph is less important than the measurements in identifying a man if he is

ever arrested again and brought to the police station. The reason is that our bone measurements change little after we are twenty-two years old. Ever after that the size of face and head, the length of arms, of fingers, and of legs are all as they will continue to be until we die.



Taking the Length and the Width of his Head

A caliper compass is used

This, then, is a sure and sensible way of keeping the record of a man. When a criminal arrives at the police court, no matter how violently he declares that he has never been there before and that this is his first offense, the officers measure him at once and also search their written records. If they find there any set of measurements which is a duplicate of those just taken, all the man's denials are in vain. Those officers know that never yet have two people been found who had precisely the same dimensions for all the bones which were measured.

It takes but ten minutes for the officers to get their record of a man — photograph and all. But it took the

man himself twenty-two years of life to make that body which is now his physical record of himself.

As a rule the body of a baby is very perfect; but even in its cradle and before it can walk a step or speak a word it begins to receive daily training of muscles and bones, of eyes and hands and brain. During these early months also older persons feel great responsibility for the child.

SEATED TO BE MEASURED

With his back against the upright scale they measure the height of his trunk

Notice any nurse or careful mother with the baby in her arms. See her hold a firm hand against the back of the head as she supports the backbone and holds the child up for a look at the world. She knows, as the doctor does, that for months there is more cartilage than bone in the supports of that small body, and that, while bones are in this condition, they cannot be trusted to do independent work.

Later, when the baby begins to walk, notice how anxious the same mother is lest the legs of the child be used too long at a time. Her fear is that those bones,

which are even now partly cartilage, may be so trained as to disgrace the body later in life. She may have heard that bowlegs often result from a disease called rickets, but she also fears lest, even without the disease, bowlegs may come from early walking; and she hopes to make it impossible for any child of hers to chide her with bow-legged records when he is grown. She knows that the younger the child the more promptly do bones bend in this direction or that, according to the treatment they receive or the use they are put to.

THE MIDDLE FINGER IS MEASURED BY A CALIPER COMPASS

Certain Indians have known this for centuries. A famous tribe that admired flat-headed men used to secure these heads for their boys by a clever contrivance. They simply fastened a board by a hinge to the head of the cradle and allowed it to press down upon the forehead of the baby whenever he was strapped in place. As months passed the small skull not only continued to grow but also set itself hard and firm in the desired shape. And, once firmly set, there was never any hope that the grown Indian could restore his head to the perfect shape which it had when he was born.

Even by accident bones often take on some unexpected and undesired shape. A man whom I know had a narrow escape from a fate of this sort. As a baby he suffered from colic, and his mother found that he was quietest in his crib when he lay on his stomach with the right side of his face on his pillow. Day after day, therefore, he slept in the same position. Then, to her dismay, one morning his mother noticed that his head was a queer-looking thing. It was slightly flattened on one side and well rounded out on the other. She was in despair at first, thinking that her child was perhaps deformed for life. But her good sense told her that there was one thing to do. She saw that the change in shape was due to the fact that the child lay always with the same side of his head against the pillow. That side had been under pressure while the other side had been growing. She therefore tried to improve matters by making the youngster sleep with his face turned the other way on his pillow.

CHINOOK BABY IN HIS CRADLE

The weight on his forehead will help turn him into a flat-headed Indian

For hours the first night the baby could not sleep. He cried and even screamed. But he was so young, so small, and so weak that he could not raise his own head to turn it over. He was really at the mercy of his mother; and the more she thought about it the surer she was that to restore the shape of his head she must compel him to sleep in a different position. Consequently she was firm, and in the course of a few days the boy could sleep as well on one side as on the other.

For many days, however, there was no change to be seen in the queer little head. Nevertheless, after three months the reward came. The woman saw that the flattened side of forehead and head had grown out as full and round as it should be. The two sides were alike once more. She had learned her lesson, and thenceforward the baby lay in his cradle with his face turned about as often to the right as to the left. To-day that boy is a college student. He weighs one hundred and eighty pounds, and his head is as well shaped as that of any member of the junior class. He has his mother to thank for this; for if he had had his own baby way, he would have ended with a head so queer that he would have been ashamed of it. And, worst of all, by the time he himself had made the discovery, the bones of his skull would have been too firmly set to be changed. Thus some of our bones and muscles are trained by other people before we are old enough

to make decisions for ourselves. Yet, whoever is responsible for results, two laws of bone growth should never be forgotten:

1. Many bones can be compelled to take a bend in this direction or that while the child is growing.

2. Almost no bone can be forced to make a new bend after it is twenty years old.

But there is other training which is more complex and for which we ourselves are responsible.

On a certain day two boys entered the same shop and asked for work. The first boy was refused, the second was accepted, and the explanation lay with the bones and the muscles which had made different records for the two bodies to which they belonged. The first boy walked with a shuffle and had a slouching body. Before he had spoken a word the business man who met him was unfavorably impressed and ready to reject him.

The second boy walked as if he respected his body thoroughly. His head was erect, his shoulders well squared, and each muscle gave the impression that he was in the habit of doing things with energy. This boy was accepted as promptly as the first was refused.

Imagine a man who needs the help of other men in carrying on some undertaking. Then try to picture the sort of body that will serve him best. Think how his success or his failure will be influenced by bone and

muscle, by the way he stands and walks, by the way he uses his back and arms and legs and feet.

Let two women enter a store or a schoolroom, a theater or a church. Which will be served most quickly, — she who shuffles as she walks, has crooked shoulders and a head thrust forward, or the woman who steps forward gracefully, who walks as if her body were her best possession, as if it were her true representative? Surely the second woman is queen wherever she goes. Without question, at every stage of growth the body proclaims the story of what has happened to it and of all that it has done with itself since it began to live.

The point of this chapter, then, is not that police measurements of size and shape make very much difference to us, but that it is more or less within our own power, while we are growing, to make the records which are to represent us the rest of our lives.

If a man by his own acts or his own carelessness must live miserably in a shanty when he might have lived gloriously in a palace, we are apt to blame him more than we pity him.

The pages of this book will show that in a marvelous way we are the architects of our own bodies. We shall also learn how to help ourselves build the sort of house that we care to live in, — the body which we are proud to acknowledge and which we are glad to see labeled with our name in full.

CHAPTER II

DANGER FROM THE SCHOOL DESK

For the sake of making discoveries about yourself, stand before a mirror and study the outline of your back, your chest, your shoulders, and your legs. Try to stand precisely as you do every day at home and at school, so that you may get a correct notion of the records your bones and muscles have made for you thus far in life.

HE STANDS CORRECTLY

(Copied from *Practical Hygiene*, by Alice Ravenhill)

Let your eyes be keenly critical. Are you standing squarely on both feet? Are your knees bent or straight? Is your back erect enough to hold your head up where it belongs, or does your head droop forward so that your chin sticks out too far in front? Are your shoulders on a level with each other, or is one higher than the other? Is your chest rounded out like that of a soldier, or is it flat and curved in like a scoop between the shoulders? Rub your hand across your back to

see whether or not a corner of a shoulder blade reaches out like a young wing starting from the wrong place.

If you can give creditable answers to these questions, your future course is easy. Simply keep on growing as you have begun, and when your bones are hard you will have the shape you wish. If, on the other hand, you are not perfectly satisfied with what you find, rectify each item of your posture separately, while you still look at yourself in the mirror.

HE LESSENS HIS LUNG CAPACITY

(Copied from *Practical Hygiene*, by Alice Ravenhill)

Stand as nearly as you can as follows: both feet on the floor, each bearing its own share of weight; both knees stiff; both shoulders square and on a level with each other. Draw in your chin until the back of your neck would touch a stand-up collar if you had one on. Inhale a breath so full and deep that your chest looks like that of a drum major ready for his regimentals. Now your back has its correct shape for standing. It should be slightly curved in its stretch from neck downwards.

Later in the day test yourself again. You are now seated. Perhaps you are in the schoolroom. If you have time for it, take different positions and note the

feelings in connection with each. First, sit with feet squarely on the floor, back straight, head erect, and chest raised. Are you comfortable? Can you draw a full, deep breath? Test this thoroughly.

Now slip down in your seat, curve your head forward, let your back be bent, let your chest fall in, and once more try to take a full, deep breath. Notice that here in the schoolroom, where your brain needs oxygen for its work, you have reduced your supply by the way in which you have doubled up your lungs.

HE CURVES HIS BACK AND CROWDS HIS LUNGS

(Copied from *Practical Hygiene*, by Alice Ravenhill)

For the sake of variety take another position. Sit with one elbow on the desk, or with one foot drawn up under you, or with some bend at the waist line that will give a twist to the spine near the hip. The objection to taking any one of these as the usual position is that gradually the relation of the bones to each other will be so altered as to give the body an undesirable shape. In no wise does it harm any of us to twist this

way and that, to bend as far as we can in one direction or another. Indeed, all such exercise is most wholesome, provided no one position is taken often enough, or held long enough, to become a habit.

Sidewise twists which have become permanent are receiving much attention from doctors and school examiners to-day. These men claim that although the large majority of the curves are very slight, and although most of them will, in all probability, never become serious, still it is not safe to allow a curve either to form or to increase after it is formed, because we cannot tell what the outcome may be.

Dr. F. A. Schmidt, a scientific writer in Germany, says that Dr. W. Mayer examined the backs of three hundred and thirty-six girls and found that one hundred and eighty-nine of the number had what is called lateral curvature of the spine. He found that girls between seven and thirteen years of age had much more trouble than those who were under seven, and he concluded that the habits of sitting formed at the school desk explained the difference, because the older children had spent more hours, days, and years in the schoolroom than those who were younger.

Another German investigator found that in a certain group of children eighteen per cent of the boys and forty-one per cent of the girls had these same curved spines. This looks as if the girls of that group had

been more careless than the boys in the way they sat at their desks. Or it may be that the boys had saved themselves by taking more exercise out of the schoolroom.

In 1907, in the great school at Rugby, England, out of one thousand boys between the ages of thirteen and fifteen, four hundred and forty-five were found to have more or less of a sidewise curve to the spine.

CURVED BACK AND HOLLOW CHEST

(Copied from *Practical Hygiene*, by Alice Ravenhill)

In America the same difficulty overtakes children in every public school.

Those who hear these facts for the first time are apt to be filled with alarmed surprise. They wonder why boys and girls who start life with beautiful, symmetrical bodies, should be allowed to develop backs with objectionable curves in them.

The answer is that, until recently, the world of thinking people has been entirely ignorant of the actual state of affairs. Few have understood the close connection between twisted backs and school desks. Now, however, the connection grows plainer every day.

Look round the schoolroom you are in and see how many of the children are doing the best they can for the spine. Draw your own conclusions from what you find. Some schools are thoroughly wide-awake on this subject. They have regular gymnastic exercises between recitations for the express purpose of saving the children from the harm which may come through long-continued sitting at the desk.

HE TWISTS HIS BACK

If he takes the same position day after day, some of the vertebræ will finally become wedge-shaped. Habits of the school desk may thus change his shape for life

(After Schmidt)

It is absurd to grow excited over the situation and to conclude that we are about to become a race of deformed people, for now that both causes and cures have been discovered there is no remaining excuse for any school of intelligent children. Let them know the danger they run and they will save themselves by the laws of prevention.

Follow for yourself the work of muscle and bone, and understand what happens when a child gets into the

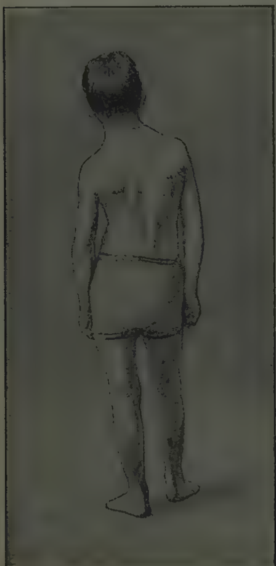
habit of sitting at his desk with elbow up on one side, shoulder lifted, and body half screwed round. Notice that if you tip up one hip the spine curves sidewise as a balance. If you raise one shoulder it pulls the spine accordingly. Evidently each separate movement of the muscles of the back brings its result in the curves of the spine, and the same curves, repeated day after day at the same desk, hold the bones and the cartilage which lies between them in wrong positions, until they are as truly pressed into a new shape as was the skull of the sleeping baby.

CURVED BY THE WAY HE IS HELD

If his nurse will carry him as often on one arm as on the other, no harm will be done to the vertebræ

So far as health is concerned, the main objection to these lateral curves is that if they are allowed to go on and become serious, they will interfere with the successful work of the large organs of the body. Then, too, when a curve becomes permanent — although it may be small — the nerves themselves are often affected by it, and the body suffers at the point which is supplied by those nerves. A person enduring this pain may not know its cause, but his ignorance will not save him from suffering.

When a medical inspector passes through the schoolroom or makes his special examination of your body, do not be alarmed. Even if he tells you that you have a little trouble with your back, keep calm and self-possessed about it; for in any case of this sort the director of physical training in your school, or some one else who understands the laws of muscle action, will give you definite directions as to what you are to do in the line of gymnastic exercises. And by being faithful in carrying out these directions you will straighten your back.



NOTICE HIS SHOULDERS

If this position becomes a habit, the boy will have a crooked body when he is a man

(Copied from *Practical Hygiene*, by Alice Ravenhill)

But prevention is best of all. Children may save themselves by being careful to balance the exercises which they allow the muscles of their backs to take. All that is needed is a little knowledge and a firm purpose. Whoever allows himself to be shaped by undesirable habits of muscle and bone will have cause for keen regret in later years. But he who, in his youth, controls his habits and shapes his body with care, will never regret it. Four rules will help:

1. Do not sit day after day in the same twisted position. When you have been seated in one way for a while, then change and sit in some other way.

2. Do not carry a heavy weight of books on the same arm back and forth from school every day. Carry as few books as possible on either arm, and let each arm do its share in holding the weight.

3. Do not carry a baby brother or sister on the same hip every day. The weight just there will tend to give a wrong twist both to your back and to his.

4. If you must stand for hours at a stretch, learn to rest one leg by using the other. Don't let one side sag down from habit. Change sides.

It is best to keep free from every form of spinal curvature by prevention; but if, through ignorance, you have been overtaken by it, you have a rare opportunity to prove for yourself what can be done with the growing human body. You will succeed if you make up your mind to it.

CHAPTER III

MUSCLES CONTRACTING AND STRETCHING

The coal heaver round the corner has a superb set of muscles over the working part of his back. They are so well developed that, as he stands bent over his work, it is evident that these muscles give him a back of tremendous strength. By their help he shovels coal for hours at a time through the days and the weeks of the year. Moreover, when he has finished his day's work he does not seem overtired. He is still ready for his joke and his laugh with his children at home. He even jokes at the expense of his own back, for although it is so well developed and so tireless, still the man himself frankly acknowledges that it is sadly bent, and that by no effort on his part can he stand straight or walk as would please him best. He says that that is the price he has had to pay for the

Bent by his Work

kind of work he has chosen as a life occupation. More people have round shoulders developed in some such way than are troubled with any kind of lateral curvature of the spine.

A bicycle rider whom I know has a back quite as bent, although from a different cause. It is muscular, strong and efficient, but it never looks well except when he is working his legs fast on his wheel. It is bent from the position it has been allowed to take, rather than from the work it has done in that position.

BENT BY BICYCLING

Something must be wrong, however, and we wonder what it is. Here are these men and multitudes of others whose backs are splendidly developed, but who are so bent as to look almost deformed. For years no one could entirely explain the cause of the combination—the strong but bent back. At last, however, close observation and logical reasoning have made the case clear. I give the explanation in the fewest words possible. The value of this explanation will be measured for us by the use we make of the law:

Muscles stay in the position in which they do their heaviest work.

A man of my acquaintance who travels a good deal, says that when, for a few weeks, he carries his suit case persistently with the same hand, that shoulder becomes an inch or an inch and a half lower than the other, while, at the same time it becomes stronger. This shows how a muscle can be lengthened even while it is being strengthened.

Stretch a muscle out and work it hard, as a coal heaver does when he curves his back over for the shoveling and the lifting of the coal, and those muscles, being obliged to work hard, even while they are stretched, will gain their strength in that position and will stay elongated even when they are not at work. Let their size and their strength increase while they are stretched and you have given them their permanent shape.

Two oarsmen illustrate this law in opposite ways. One does all his hardest rowing with a straight back, the other with a back that is curved. Their work continues day after day until each back is as strong and as muscular as the other. But see what the results are. One man walks as if he had spent his boyhood curved over a school desk without a thought about what might be happening to his spine. The other man looks as if he might have spent those same years at West Point with officers and fellow-students who compelled him to stand

straight whether he wished to or not. Yet the boyhood of the two men may have been the same. Indeed, the difference just now lies entirely with the two positions in which they did their rowing. Their muscles, when they walk, simply betray some facts about their recent history.

BENT BY AGE

Look at the hand of a piano player,—it is open because he always exercises it hard in that position; and the hand of the oarsman,—see how his fingers curl up as if they were ready to grasp his oar even when it is not in sight. An oarsman's hand tells the story about his occupation.

From the man who digs to earn his daily bread on the farm or in the coal mine, to the man who climbs a mast and risks his life in the tempest,—through each occupation of life the muscles of the body are called upon to do their hardest work in special positions. And it sometimes seems as if numberless human beings would have to submit to their fate and accept muscles which their work has forced on them; for after a man has chosen his life work he cannot leave it simply because he objects to the shape which it is giving to his body.

Fortunately, however, there is a happy outlook even for such people as are obliged to work with their backs bent, for there is another important fact about this law of contracting and stretching. I give it concisely:

Brief, vigorous exercise in the right position will undo much of the harm of long-continued exercise in the wrong position.

If a man who works in a bent posture all day will spend five minutes a day in taking vigorous exercise with his back straight, alternately tightening hard and then relaxing the muscles of his back and neck, he will find that, within one month, there will be an improvement. By this simple device a man may save himself from his rounded back and be able to hold his head where it should be.

Let the oarsman who objects to hands that curve like stiffened claws spend several minutes each day in first extending his fingers forcibly, then in relaxing them, and he will be sure to see results.

From these facts we learn that by the vigorous exercise of one set of muscles for a few minutes each day, we may be able to overcome the harm which is done by the long-continued plodding work of another group of muscles.

It often happens that the muscles of the chest become thin and flabby for lack of exercise, even while the back has become very strong. But these muscles may

be saved. Throw the shoulders well back and exercise chest muscles hard in this position. Exercise them while they are thus stretched and they will grow large and prominent in spite of what the man's occupation may be.

In this work of changing the shape and the power of a muscle the greatest strain must be put on the last third or the last quarter of the contraction which it makes. Remember that each muscle is inclined to stay in the shape which it takes when it does its hardest work; in other words, the law of the body is that doing a thing makes the body shape itself to that act.

CHAPTER IV

THE MUSCLE ITSELF

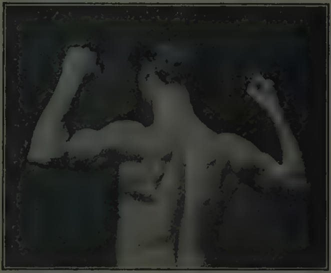
The audience was greatly interested, for the doctor who gave the lecture had just said that, with very little trouble, each man present could increase the size of his arm three quarters of an inch within one month, and could increase his chest measure an inch and a half during the same length of time. Those who listened were business men, and they were specially pleased with the part of the lecture which told them how they might set to work to secure this astonishing growth for themselves.

Exercise for the Biceps

To show what he meant, the lecturer asked his friend, a medical student, to illustrate the points one by one as he himself explained them. The student was well-knit and well-built. No unnecessary fat concealed the shape of his muscles, and he was ready to show the other

men what they also might do in behalf of their own development.

For a while it sounded as if the whole talk were to be a lecture on the size and shape of different muscles; for the doctor asked his friend to show his muscles one after the other in quick succession. "Now," said he, "show us the effect on the biceps of rotating the arm; the forearm; now the leg, — the big muscles; show that tensor. Now again will you go through four or five exercises that bring into play in succession first one arm, then the other, and so on?"


WELL-DEVELOPED MUSCLES

The student acted on the suggestions as fast as they were given. His smooth back and arms gave no sign of separate muscles while he stood quietly waiting to be told what to do. But as soon as he followed directions and used arm, leg, back, or shoulders, there sprang into view a succession of splendid muscles that seemed to have been lying in ambush under the skin.

From his intense expression it was evident, however, that in order to force these muscles into action and into sight, the young man fastened his utmost will power and attention on them. In doing this his joints had to stiffen themselves for the stronger resistance, while at

the same time the muscles of the entire body seemed to be brought into active exercise. They worked together, although the special force of each exercise was of course centered on the muscle which was being developed.

In all this the student held no apparatus, but he used arms and legs as if he were pulling against some invisible weight. He was, in fact, pulling against the force of his own other muscles, — antagonistic muscles they are called. Try this for yourself with your forearm or with your back. Decide to bring out one muscle and see how many others are called into action.

Exercise without Apparatus

The lecturer then explained that muscles can be developed in this way with no apparatus whatever. He said that the power lies in making certain muscles pull against their antagonistic muscles. As he gave his directions he added that muscles must pull as hard as possible for a few seconds at a time, must then let go completely, then pull again for a few seconds, and so keep up the alternation for five minutes in the morning, for five minutes at night, and for ten minutes a day between times. Men who proposed to develop arm or chest could, he said, put in the extra ten minutes whenever convenient.

It seems that the different pulls do not need to be in close succession, but may be slipped in anywhere during the day. The whole process of developing a particular muscle or set of muscles may thus be carried on without apparatus, without gymnastics, without fuss or feathers or display in any direction. The student testified that what he had done for himself in this way had increased the size of his own arm an inch within a single month.

He develops Arm Muscles

As for securing really big muscles, however, anything enormous is a disadvantage rather than an advantage in the health line. Still the fact that up to a definite limit we have the power to increase the size of arm and chest and leg proves once again how truly each of us is master and architect of the body we are building.

Taking the Measurement

But what about the material itself — the substance out of which the body piles a muscle into shape and compels it to increase in size whenever it is forced to do unusual work?

Get a piece of lean corned beef from the butcher; have it boiled thoroughly; place a board over it and press down upon it hard enough to squeeze out all the liquid; remove the board, and with a needle of some sort pick apart the fibers as well as you can. Pick them away from each other into finer and finer threads until you think you have reached the limit in size.

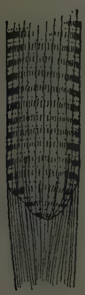
Muscles of Different Shape
(After Schmidt)

Now if you can get a good magnifying glass, use it in examining one of these bits of beef muscle. You are able to pull them apart because the outside wrapping of each has been changed by boiling.

However large or small a muscle may be, and wherever that muscle does its work, — whether in creatures that walk or fly or swim, — every active muscle is made up of fibers wrapped together in bundles. Shapes are different; size varies from those that draw an eyelid up and down to those that kick a football to its goal; location is different; strength

and power of endurance are different; but each muscle that has ever been studied has been found to be made up of fibers. A few of these are wrapped together as a small bundle. Small bundles are gathered into bundles that are larger. Large bundles become larger yet; and thus from smaller to larger are the muscles built up. Each is a bundle of other bundles; each is adapted in size and shape to the special work which it must do; and every fiber in the bundles, large and small, is inclosed in its own sarcolemma. This sarcolemma, then, is simply an outer wrap which separates each fiber from all the others. In addition, however, there is a close network of substance called connective tissue, which holds the individual fibers together. In this connective tissue are the tiny blood vessels and the slender nerves which supply blood and stimulus to each smallest fiber of the largest as well as of the smallest muscles of the body. Fine threads of connective tissue also stretch away from each end of the muscle fibers and help form the tendon. Thus, although each separate fiber is a part of the muscle

Individual Muscle Fibers

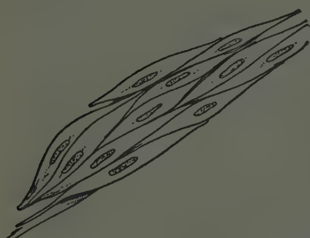


End of a Muscle Fiber

It shows fine threads which help form the tendon

as a whole, it also seems to be an independent small center of power doing its own independent work.

The truth, however, is that no single fiber carries its independence very far. Generally when its neighbors receive your command to go to work, it receives the same command. When they rest, it rests too. When they are destroyed by suffering, age, or death, it endures all that they endure. Yet, after all, the work of the millions of fibers which are held together by connective tissue in a single muscle is really the sum of the work which the fibers do separately.



A Bundle of Muscle Fibers

Each is covered with its own sarcolemma; connective tissue is between the fibers

More than this, it is the amount of connective tissue between the fibers that explains the difference between tough and tender meat. With age and with exercise this tissue gradually thickens its substance during life until finally certain muscles become too tough to be eaten without long boiling.

A spring chicken is tender because its tissue has not been toughened by work. Tender steak comes from that part of the animal which has had little exercise. When, therefore, we speak of tough and tender meat we really refer to muscles in which the connective tissue has been toughened.

SUPERFICIAL MUSCLES OF THE BODY

Each is fastened to bones that lie underneath

These facts apply not only to the muscles of those animals that are killed by human beings for food, but also to our own arms and legs. Let an athlete bend up his arm for your benefit. You may try to press it with your hand and it will resist you almost like a piece of wood. This is no mystery to you, for you understand that each fiber in that muscle has been toughened by use. If the muscle itself were found in the shop of a butcher and were offered for sale, a wise cook would refuse to buy it. He would complain that even boiling would not make it tender.

These muscles which we have been studying belong to the skeleton. They are always attached to bones and are therefore called skeletal or voluntary muscles. There are indeed two classes of muscles:

1. Voluntary muscles, of which there are five hundred. They are called voluntary because each is under the power of our will. Through them we walk and run and climb and swim; through them we talk and sing and play the piano and cover ourselves with glory on the athletic field. They serve us when we give our commands. Not so, however, with the second class.

2. Involuntary muscles. These form the heart and are also in the walls of the arteries and of the alimentary canal, — the food tube. They are deaf when we command, but they continue to be busy

whether we are asleep or awake; whether we stand or sit; whether we laugh or sigh or cry, run or climb or swim. Whatever we do, they are unceasingly occupied with the internal work of the body, — pumping the blood round through heart and blood vessels, caring for the food we eat, and carrying on those central, vital processes of life over which we have no conscious control.

Taken as a whole, the muscular machinery of any human being weighs as much as all the rest of his body put together and weighed in a lump. A few separate muscles are given in the picture, but there is no special reason why we should learn their names by heart. Nevertheless the biceps is not easily forgotten. It is the muscle best known to every boy, for it may give him pride or disgrace him, according to the pulling power which has been developed in it by its master.

CHAPTER V

STIFF SUPPORT FOR GROUPS OF MUSCLES

A certain teacher who owned a skeleton was in the habit of throwing it over his shoulder when he carried it from the storeroom where he kept it to the lecture room where he showed it to his students. And as he walked it hung from his back as a clattering set of dangling bones. It is true that the separate bones were held together at the joints by artificial contrivances; but that was all. By no chance could the skeleton have stood on its own unaided legs. Those who saw this group of bones for the first time understood as never before that bones are as dependent on ligaments and muscle to keep them together as are tendon and muscle dependent on bone to hold them in place.

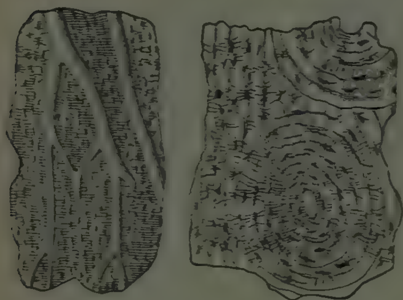
Examine a bone fresh from the butcher's. Notice the outside, — firm and closely woven, as it has to be, to supply a surface for muscles to hold to. Look at the inside. There we find looser texture. We know now how it happens that the bone is not only large and strong but light and firm. It is indeed by no means a solid thing. A magnifying glass shows the spaces even better yet. You may now see smooth channels on the outside,

THE CENTRAL SUPPORT OF THE HUMAN BODY

A, skull (composed of 22 bones); *B*, spinal column (composed of 33 vertebræ); *C*, sternum or breastbone; *D*, ribs (12 on each side); *E*, clavicle; *F*, humerus; *G*, radius; *H*, ulna; *I*, carpal (7 bones in each wrist and ankle); *J*, metacarpal (5 bones in the palm of each hand and instep); *K*, phalanges (14 bones that form the fingers and the toes of each hand and foot); *L*, pelvis (composed of 4 bones); *M*, femur; *N*, tibia; *O*, fibula

along which the blood vessels ran, and tiny openings from the surface to the interior, into which the smallest blood vessels went, to keep up the life of the bone.

A chemist will take the same bone and study it in another and a different way. He will keep it in acid for a while and will then tell us that he has taken all the lime out; that he has left nothing but gelatin. He may tie it into a knot and let us see how pliable it is. Taking another bone, he will hold it in fire for a while, and when we touch it the whole structure will go to pieces like a heap of ashes. "That is mostly lime," he will tell us; "I have burned out the organic matter which becomes gelatin when boiled." A cook will take a bone with no meat on it, will boil it for several hours, set the liquid away to cool, and when it is cold she will have a thick jelly to add to her soups. It is gelatin made from the bone. From these and other experiments we learn that bones are made up of lime and of an animal substance, which becomes gelatin after being cooked. We also learn that in old age bones



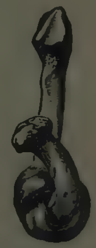
A *B*

Bone cut Lengthwise (*A*) and Crosswise (*B*)

Blood vessels and nerves run through the canals, and these canals are joined to each other by channels yet more minute

contain the most lime, and that the younger the child the less lime is there in his bones.

It appears that the proportion of lime increases from year to year through life, until finally the entire system of bones becomes too brittle to make it safe for aged people to risk even so small a thing as a tumble on the sidewalk. Many an older bone has snapped off short where a younger bone would have saved itself by bending a trifle.



TIED IN A KNOT

After acid has taken the lime from it

This brings us back to the subject of the reason why children have the power to influence the shape of their bones while they are young. The animal part not only prevents bones from being brittle, but it keeps them pliable.

Knowing this fact, I applied it to the case of a friend of mine. She was getting a hollow chest and I told her how to save herself. "It will be hopeless after you are twenty," I said. "But you are only twelve now. Your bones are still pliable. If you will raise your chest with vigor, fill your lungs with air, hold yourself in this position for three or four seconds at a time and do it many times a day, you will compel your bones to take the shape for which you will be thankful the rest of your life." I suggested that she give special attention to the matter on the way to and from school each day. She liked my scheme so

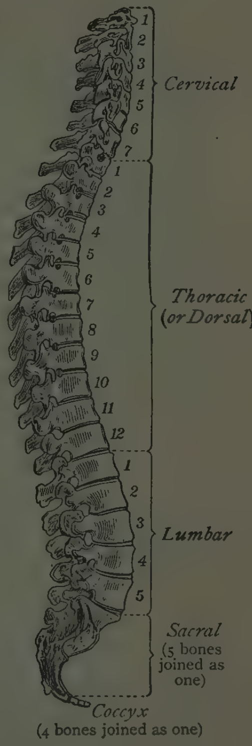
well and practiced it so faithfully, that within a month the curve of her chest had improved. Cities are full of women who, if they could thereby improve their appearance, would gladly take hold of their bones one by one, and pinch and pound them into a desired shape. Such women have grown up without knowing what we have learned already, that during youth, through the aid of muscles and firm determination, the relation of bones to each other may be quietly turned in this direction or that according to our own desire.

A BONE CUT THROUGH LENGTHWISE

The outer layer is compact and firm, the inner substance is a network of canals and spaces; thus are bones both light and strong

Although young bones are pliable, they are nevertheless firm enough to be the central support of the entire body of the youngest child. See a baby kick his small legs and thrash his arms about. His bones are not yet strong enough to bear much weight, but they supply just as many points for muscles to hold to as do older bones. They also have just as many different shapes as they will ever have. Each bone is as important to the body of a child as to that of a man, and ignorance about them is a misfortune.

In so far as you can, feel of your own bones and decide for yourself why each has its own particular shape. You will find long bones for legs and arms; flat bones for shoulder blades, breastbone, and hips; curved long bones for the ribs; curved flat bones for the skull; and you will discover that these latter are so closely joined together that your head seems like a solid, single bone. There are queer, jagged bones, one above the other, in a column for the back, and many small bones of hand and foot deftly held together, each doing its part in stiffening up the body and in making it serviceable to us.



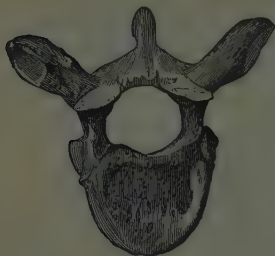
SPINAL COLUMN, SIDE VIEW

Each group of vertebræ has its special name

Baby and man alike have the same number of pieces to the skeleton, but the names of our two hundred separate bones are of no vital importance to us. Still the picture gives a few, because it seems almost discourteous to label such useful articles as nothing more than long and short and flat and crooked bones.

Most important of all, perhaps, is the graceful column of the spine. Many a man has lived for years without

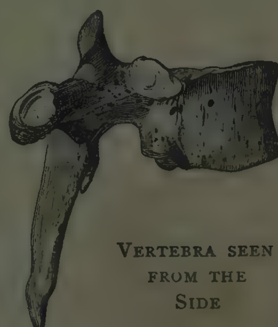
an arm, without a leg, without bones of various size and shape; but no man has ever been able to live for a moment without that pile of thirty-three small bones



Vertebra seen from above

that holds his head erect, that keeps his ribs in place, and that guards the treasure of his spinal cord.

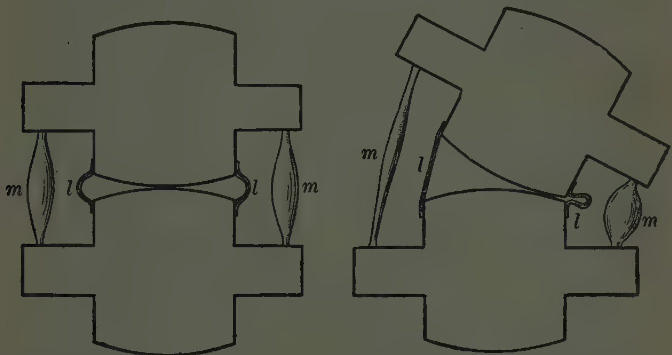
In this spine each separate vertebra is held to the one above it and to the one below it by muscles and ligaments on each side, and because of their muscles and ligaments these individual vertebræ are no more responsible for the shape they take, or for the twists and curves they join in making when a gymnast bends his back from side to side, than are the dumb-bells and the pulleys which the same gymnast uses; for the bones of the spine simply rock back and forth upon each other according as muscles on this side or that give the needed pull.



Vertebra seen from the Side

Just here recall a few facts. As we know, young bones are largely cartilage; they take new shapes if they are put under special, oft-repeated pressure. A child at a school desk easily gets into the habit of sitting with the vertebræ

pressed against each other at the same angle every day. Small muscles do the pulling; they grow strong as they are exercised. In the meantime, also, the separate vertebræ are yielding to pressure. On one side they are growing thinner; on the other side, not being pressed upon, they grow thicker. The result is inevitable. Some of



BLOCKS TO SHOW HOW THE VERTEBRÆ ARE HELD TOGETHER BY LIGAMENTS AND MUSCLES

l, ligament; *m*, muscle

the bones of the back will become wedge-shaped; and, sad to say, a back that has developed wedge-shaped vertebræ — vertebræ that have kept their wedge-shape until they are hardened for life — can never hope to be straight again.

Certain other bones may, however, be changed by what they are compelled to do. Suppose you decide that you wish those that are larger and rougher. You

Wedge-shaped Vertebræ

Pressure was too often on the same side

may travel a straight road to that definite end. Work the muscles which are fastened to these bones; work them hard; be persistent and the result will come.

In studying human skeletons it is not difficult to pick out the bones of such persons as did vigorous muscular work by their heavier and rougher character, while the thin walls and fragile internal substance of other bones show that the muscles of the arms and the legs were paralyzed or wholly useless.

Evidently, then, active exercise leaves its mark even on the bony part of the body. Thus, without making any close examination of our own separate bones, we may know, by the exercise we give them, what their prospects are year by year.

CHAPTER VI

BONDAGE AND FREEDOM FOR THE FEET

As I looked at the small, deformed feet of our friend the Chinese lady, I easily imagined what had happened

CHINESE SHOES TWO AND A HALF INCHES LONG

The huge ankle shows how deformed the foot really is

to the bones that made up the bulk of the huge ankle above the shoe. No one saw this ankle. All we saw

was the dainty, handmade shoe two and a half inches long, embroidered in silk of lovely shades, and made of cloth and silk above a leather sole.

For hundreds of years Chinese custom demanded that all the women of the upper classes in the empire should hobble through life on deformed feet. Some feet were larger, some were smaller, but in certain regions the most stylish shoes were two and a half inches long. This, then, was the size of foot which the ladies wished to have. To secure it, a mother began to bind the feet of her daughters when the girls were five or six years old. Often the girls themselves wished to have this done. Nevertheless the bandages were drawn so tight that, night after night, young girls have cried themselves to sleep in China because their feet in their bandages hurt them so.

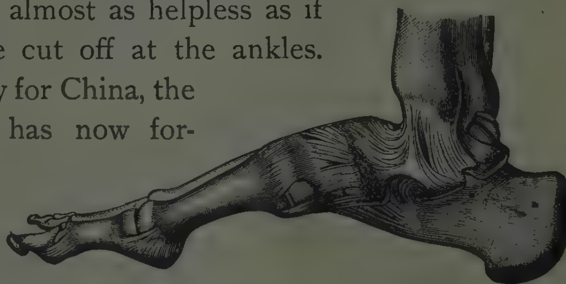
THE BONES OF THE FOOT

Almost never, however, were the bandages left off. They were changed from time to time. But when they were put on again they were pulled ever tighter, until, in the course of years, the child secured the foot which could never again help her by the movement of the bones which formed it. The toes had been drawn in under the foot; the heel had been drawn forward to

meet them; muscles and tendons had been kept from growing, while the bones themselves had been obliged to take strange new shapes as they fitted themselves into such space as they could get.

When I saw my friend the Chinese lady, her feet were set for life. They gave her little discomfort, and she herself now took entire charge of their binding. Until she dies, however, she must hobble through her duties and her pleasures almost as helpless as if her feet were cut off at the ankles.

Fortunately for China, the government has now forbidden foot binding throughout the empire. At last, therefore, the girls of the land may sleep in comfort, and the future ladies of the Celestial Empire may walk about with such ease and grace as can only come when the entire foot is at the service of the body.



Bones and Ligaments of the Foot and Ankle

Even in other lands than China there is often lack of comfort, while very often all trace of grace is also lacking. When you see your own bare foot to-night compare its natural shape with the shape of fashionable shoes. Remember the following facts and decide what the sensible course of action is:

1. Each foot is made up of twenty-six small bones.

2. These bones are joined to each other by ligaments and muscles.

3. No foot can be in thoroughly good order, neither can it exercise itself with ease, unless each muscle, bone, and ligament is allowed to move with freedom.

4. If the arch of the foot is flattened, health is apt to suffer. Indeed, it is so serious a matter to be flat footed that men with this handicap are refused admittance to the United States army. Test the condition of the arch of your own foot by dipping the bare sole lightly in water, then pressing it on blotting paper. The imprint made will show whether the foot is flat or arched. Those who stand still for hours every day are in danger of flattening their feet. While they stand they should therefore save the arch by resting the weight of the body first on one foot for a while, then on the other. If you have any tendency to flat feet, help yourself by the following exercise. Stand with toes turned inwards, and while in this position rise as high as you can on your toes. Do this one hundred times, twice a

FOOTPRINTS

A, an arched foot; *B*, a flat foot

(After Schmidt)

day; or, instead of counting, rise and fall on the toes until the muscles are tired.

5. A young foot grows by day as well as by night, and should never be cramped when it is in use. This does not mean that a shoe should be too loose for comfort. It means that the foot is one of the most useful pieces of machinery we have, and that we are in better health and have a more graceful walk when our feet are not uncomfortably hampered by our shoes.

A Woman's Foot deformed by Fashionable Shoes

(After Schmidt)

It is a sad fact that multitudes of men and women would be filled with confusion if they were obliged to show the shape of the feet they have secured for themselves. The explanation of the shape lies, of course, in the shoes they have worn.

The best health of the foot calls for attention to the following points:

1. Wear shoes with soles as broad as your foot is when you stand with no shoe on.

2. Do not lace your shoes so snugly about the ankle that the pressure will interfere with the

circulation of blood. Cold feet often come from tight shoes, tightly laced.

3. Let the heels of your shoes be broad and low.

A *B* *C*

THE SHAPE OF THE FOOT AND THE SHAPE OF THE SHOE

Dotted lines show the natural shape of the foot; solid lines show the sole of the shoe. *A*, correct shape; *B*, the large toe is drawn in too far; *C*, the shoe is too narrow. If you wish a comfortable and a well-shaped shoe, get one that is wide enough, but longer than you need. This will give you the effect of having a slender foot

4. Never wear tight garters. They interfere with the movement of the blood through the blood vessels.

5. Remember that tan shoes are rather better than black shoes for summer wear because they do not keep the feet so warm.

6. Keep the feet dry and warm, but, if possible, avoid overheating them.

7. Be sure that your shoes are large enough to give your toes as well as your ankle a chance to move and to be useful when you walk.

When the school children of the world turn their serious attention to the subject, and put into practice what they know about healthy feet and about shoes of the proper shape, they will form an army which will have the power to lead the fashion of the world in sensible shoes.

CHAPTER VII

ASSISTANCE FROM JOINTS

During the summer of 1905 the following item appeared in the New York *Times*.

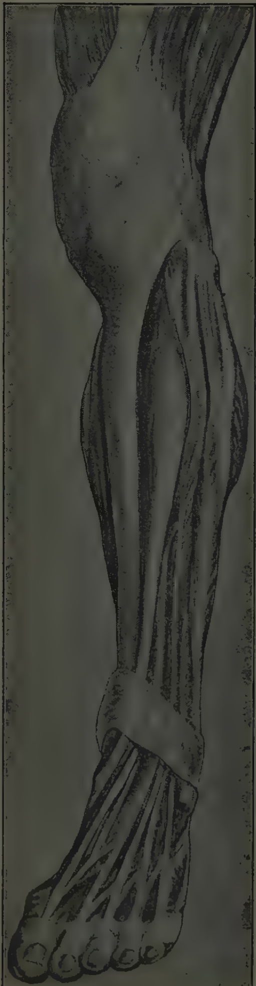
ELEPHANT'S ANKLE SPRAINED

Alice slips on a Banana Peel and gets a Bad Twist

Alice, the big elephant in Bostock's at Coney Island, has a sprained ankle. It is a bad sprain, too, mainly because it is a big one; there is nothing slender about Alice's ankles. Alice was crossing a gangway into the arena when she slipped on a plebeian banana peel.

Alice saved herself from falling by winding her trunk around the leg of her mate, Roger. Alice's ankle is now in a big plaster cast, which makes her leg look like a huge fireproof pipe.

No doubt Alice, the elephant, suffered as much from her sprained ankle as did my friend Alice, the human being, who sprained her ankle at about the same time by slipping on another banana peel. In each case ligaments that held the bones in their sockets and tendons that held the muscles to the bones were more or less pulled from their firm fastenings. And when a pull does as much mischief as that, recovery is often slower than in the case of a broken bone.

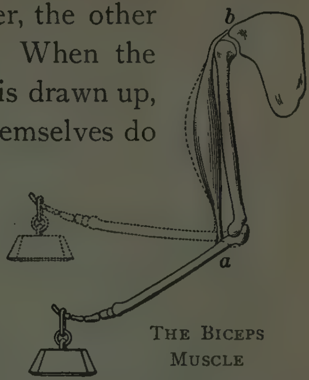


Lower Leg with its Muscles and Tendons
(After Schmidt)

Bend your own ankle in every possible direction and learn what you can about it from your sensations as you twist it. Draw up the muscles in the calf of your leg so hard that you think you feel the spots where they are fastened to the bones above and below. Now recall facts which you know, and decide what is taking place. Remember that muscles end in tendons, and that it is by its tendon alone that a muscle is able to move the bone which supports it.

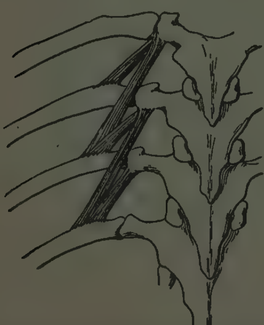
For the muscle of the calf of the leg, tendons are fastened to the lower end of the thigh bone and to the heel bone, and the work of contracting is done between the two firmly held points. Through this muscular contraction we walk and jump and run to win the race or to take our exercise. Tendons must be strong indeed when they refuse to give way even under the tremendous strain which is put upon them. Follow the facts about the biceps. It is fitted for one particular kind of work, and it does

its work through the help of tendons which hold one end of the muscle to the shoulder, the other end to a bone of the forearm. When the muscle contracts the lower bone is drawn up, because, although the tendons themselves do not contract, they cling to the bones and thus help do the pulling. Without tendons, indeed, no muscle could ever move a bone. Muscles of the back are held to the spine, which they control by tendons; neck muscles hold the head in place by tendons; and each of the twenty-four ribs has its own supply of muscles and tendons. By the contraction of the muscles the tendons pull the ribs up where we wish them to be.



THE BICEPS MUSCLE

When it contracts the lower bone is drawn up; the dotted line shows that the muscle is then thicker and shorter



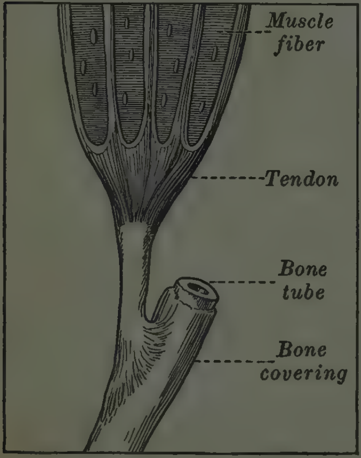
MUSCLES BETWEEN THE RIBS

When the muscles contract the ribs are drawn up

The serious part of strained tendons is that the union of tendon and bone is so close that, in a bad sprain, the outside covering of the bone itself is sometimes pulled away with the tendon. When this happens a sprain is a far more serious affair to cure than a clean-cut bone break; for the broken ends of a

bone knit together far more readily than do the torn ends of a tendon.

After all, however, the ligaments and bone surfaces are quite as important to us as the tendon, because they determine the direction in which a bone must move. Some of them allow movement in one direction, some in another. Prove this for yourself. By every twist that you can make, try to decide where your joints are and what style of joint each one is. You will find that some work back and forth like a hinge, while others have the power to move back and forth and sidewise too. The different kinds of movement are the result of different kinds of joints. Each is needed in its particular place.



MUSCLE ENDING IN TENDON; TENDON FASTENED TO BONE

(After Schmidt)

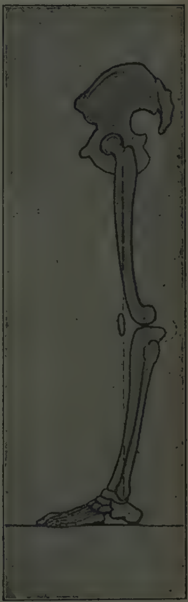
Begin with the hinge joint where your skull is joined to the upper end bone of the spine. This allows you to bend your head up and down, and nothing more. But just below, between the next two bones, is a joint of another sort. This allows you to turn your head from side to side. Thanks to the two joints acting as one, you can move your head in every direction.

Whirl your arm round and round and know that you are using the most movable joint in the entire body. It is a so-called ball-and-socket joint. The hip is supplied with another of the same kind.

When we think of the work which the hip and the knee have to do for us, and of the strain we are ready to put on them at any moment, we understand why the hip and knee joints should be among

Hip Joint drawn open

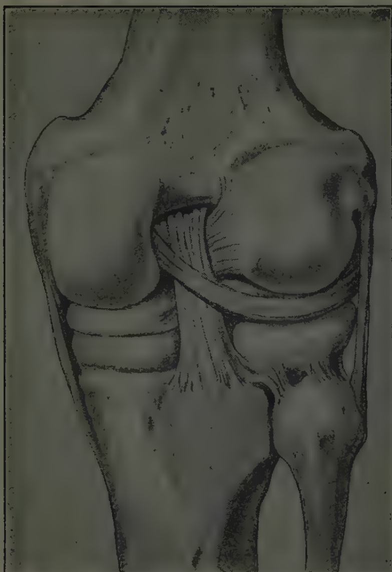
Notice the ligament which holds the ball in its socket



Bones and Joints of the Leg

the firmest and the strongest points of the whole body.

The knee itself is a wonderful structure. And here we have an admirable chance to study ligaments. They are firm and white and tough, being in all this quite like



THE BACK OF THE KNEE JOINT
(After Schmidt)

tendons. Moreover, when once torn they are as slow to heal as is a tendon. Ligaments do the work of holding bones to each other, whereas tendons hold muscles to bones.

The great hinge joint of the knee is supplied with ligaments which allow it to bend one way, but which absolutely forbid any bending in an opposite direction. If it were not for the stout ligaments which hold the bones together in a definite relation, our knees would bend backwards and forwards with equal ease, and walking would be forever out of the question.

CUT THROUGH THE HINGE JOINT OF THE ELBOW

Elbow as well as knee, fingers as well as toes,—all act on the plan of the hinge.

Two kinds of joints are thus seen to be most prominent in the body of man: (1) ball and socket; (2) hinge.

This completes the outline of the bony and muscular machinery of our bodies. We have seen that the ends of our bones are shaped to meet each other, that they

KNEE JOINT WHEN STRAIGHT

Notice the position of the knee pan

(After Schmidt)

KNEE JOINT BENT FAR OVER

Notice the ligaments that hold the bones together

(After Schmidt)

are carefully fitted together, that tough ligaments hold the one to the other, and that muscles end in tendons which draw the bones in such directions as the joints allow.

CHAPTER VIII

THINGS THAT HINDER STRENGTH AND SPEED

Various public schools were in a state of high excitement during the spring of 1905. The following item in the New York *Times* shows the reason for it:

> Schoolboy athletes are to hold their contests on the roofs of the available public school buildings in the boroughs of Manhattan and Brooklyn. . . . Each school is to enter five boys in each individual event, and two teams in each relay race. Medals will be given to first, second, and third in each event, and a trophy will be presented to the school scoring the most points.

Boys under thirteen, in these events, competed in the potato race, the standing broad jump, and the relay race for teams of four boys, each running twice across the roof. Boys under fifteen had the same potato race, with running high jump instead of broad jump; and in the relay race of four boys, each ran four times instead of twice across the roof. Boys over fifteen did other things in addition.

Throughout the spring of that year, wherever New York boys could find a roof large enough or a space of ground unoccupied, there they went for fun, for exercise, and for trophies. But the doctors of the city, the fathers, the mothers, and the teachers believed most in the exercise.

They were sure that through it city boys might gain the greatest prize of all — good health; and they were more anxious to have the city turn hundreds of thousands of boys and girls into healthy, well-developed, long-lived men and women, than to have it turn out a few wonderful athletes who should outrun and outjump all other boys in all other cities in America.

THE START AND THE FINISH OF THE HUNDRED-YARD RUN

The truth is that never before in the history of the world has so much attention been paid to the health of children as in this twentieth century; for, in the first place, the laws of health are better understood to-day than ever before, and further, the children themselves are learning to judge what is best for the body.

Perhaps city children need this knowledge most, for, in some ways, they have most to contend against. In

tens of thousands of cases real exercise for city children is quite out of the question. City streets are too narrow; they are too full of cars and carriages, of men and women and hurrying business of every sort. In such places groups of running boys and girls are a nuisance, — they are impossible. And just because of this, athletic leagues have been devised to help out the situation. The great object of these leagues is to give wholesome exercise to the bodies of such school children as are old enough to take it. The way this is managed in New York City is most businesslike:

1. The boys in each separate school of each of the forty-six school districts are allowed to compete with each other, and the best are chosen champions of each school.

2. These champions compete with the other champions of the schools in the same district league, and the successful school becomes champion of the district. There is then a joyful celebration, to which an officer of the city league comes. He not only listens to the music and the speeches by the pupils, but, at the proper moment, he too makes a speech and presents to the school the trophy it has won. Sometimes this trophy is a graceful silver cup, eighteen inches high, bearing the date of the victory and the name of the school. Sometimes it is a burnished bronze tablet to be hung on the

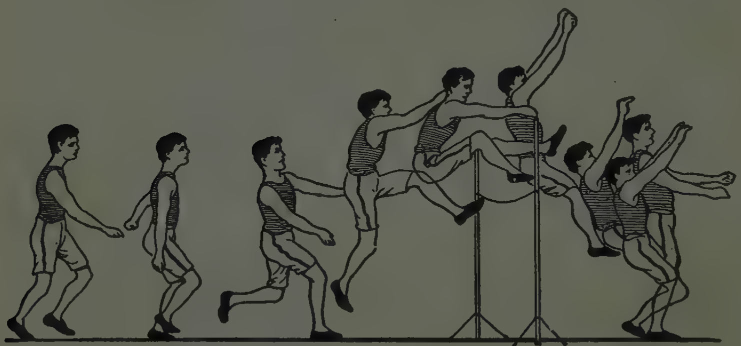
school-room wall. In every case it is to stay with the school for a year at least, and so long thereafter as the school can continue to hold the championship of the district.

3. The champion school in each district league competes with each of the other league champions, and the victor becomes the champion school of the city. No school in the league can win a higher place than this.

AN ALL-ROUND CHAMPIONSHIP TROPHY OF THE PUBLIC SCHOOLS ATHLETIC LEAGUE, NEW YORK CITY

The beauty of these contests is that, from the very start, no boy feels that he works for himself alone. Instead, each victory means victory for his school. Fellow-students cheer him, for they know and he knows that he has won success for them as well as for himself. For this reason each boy is most anxious to get the best possible service from his body, and many boys are shrewd enough to make a special study of the laws of success and failure. They are ready to do such things as help, and to avoid such things as may hinder, their success.

This accounts for the self-denial which many of them practice. They have learned that the best athletic trainers of college teams and of professional athletes throughout the country strictly forbid their men to use tobacco in any form. The boys also know that the reason for this is the fact that tobacco so affects the heart as to reduce a man's ability to do his best muscular work.



A High Jump at Nine Consecutive Moments
To do his best his heart must be in good condition
(After Schmidt)

Boys have learned from these same trainers that alcohol is strictly forbidden because it reduces the power of the muscles. Being keen enough to see that that which helps college students and professional athletes is precisely what will help them, the most determined of these boys give up their cigarettes and do not so much as begin to use alcohol. Multitudes of other boys are, of course, still smoking cigarettes, but in

thousands of these cases ignorance explains their willingness to do it.

Any class or school that is interested in making scientific investigations for itself might appoint a committee to look into the school records and into the running and jumping records of their smoking and their non-smoking classmates. Investigations of this kind must be carried on for months, or for a year if they are to prove anything.

MUSCLES TIGHTENED FOR THE JUMP

(After Schmidt)

As a rule, at the end of this time it will be found that those boys who use the most cigarettes are doing the poorest work both in the class room and on the athletic field. The class or the school that wishes to make the best records will therefore be forced to omit from among its contestants all those who use cigarettes. It will decide that it cannot afford to reduce its chance for winning just because certain boys are either ignorant about the laws of the body, or because they are already victims of the cigarette habit.

Why did the American army have to refuse hundreds of men who applied and who were ready to face death for the sake of their country? In a large number of cases it was because these men had a certain weakness of the heart which was brought on by tobacco, and because, when a man's heart is troubled in this particular way, he is not likely to be able to endure the exercise which he will have to meet as a soldier. His heart is not strong enough to risk it.

A Running Broad Jump from One Foot

It shows the work done by different muscles from the moment the man jumped until he stood on his feet again

(After Schmidt)

The same is true for athletes of every age and size in whatever land they may be. He who is in the habit of using cigarettes should be careful how he ventures to do anything that will call for sudden, or violent, or vigorous use of his muscles and his heart. Although he may still be able to run as fast and to jump as high as his friend or his schoolmate who does not smoke, yet the probability is that he has the sort of heart that the American army often refuses to accept, — the heart that no soldier can afford to own. And the man who is

afflicted in this way cannot expect to do his best on the athletic field.

In this connection it is interesting to know what the leading trainers of the country actually say about it.

Mr. Charles E. Courtney once wrote from Cornell:

> I have found in my experience that young men are much better off, and do better work, without alcoholic stimulants than with them, and they are, therefore, absolutely prohibited in our training. As to tobacco, I believe young men do better work when not using tobacco than when using it, and it is prohibited in our training here at Cornell University.

In 1900 Mr. McBride, captain of the Yale football team, wrote:

> It is absolutely necessary for a college or school athlete who is striving to win a place on any team to have endurance; especially is this true in rowing and football. This can be accomplished to the greatest degree only by abstaining from the use of tobacco and alcoholic drinks while in training for said team.

In 1901 Mr. Edwards, captain of the Princeton football team, wrote:

> There is nothing which goes to make a better athlete, nothing which gives a man greater power of endurance, than total abstinence from the use of alcoholic drinks. . . . No one is expected to use tobacco. A man who is using tobacco and alcohol contrary to orders during the season is easily detected, and is dropped from the squad.

In 1906 Mr. A. A. Stagg of the University of Chicago wrote:

> We have never had a really successful long-distance runner at the University of Chicago who was a smoker, and several of our men who

have been successful, like Lightbody, are most abstemious in their training and do not smoke. The best sprinters and middle-distance runners we have had have also been men who were very particular about their training for several months of the year. . . . In football, as in other endurance tests, there is no question at all in my mind that the man who smokes does not come up to the level of the general run of nonsmokers.

In 1906 Mr. Gianini of the New York Athletic Club wrote:

My opinion is expressed best by stating that I forbid the use of tobacco in any form by men under my charge while training.

The Arctic traveler, Nansen, was asked by a neighbor, "Did you take any alcohol with you when you left the Fram to make your heroic expedition by sledges?" "No," said Nansen, "for if I had done so, I should never have returned."

In 1918 the United States established what was called a "dry zone" around every army and navy camp in the country. This meant that not a soldier or sailor in those camps was allowed to use any alcoholic drink. Alcohol was kept from them for just one reason. The country had entered the World War, and for the sake of victory, for the sake of having each man ready to do his utmost in winning the war, alcohol was kept from him.

CHAPTER IX

THE HEART WHEN IT IS AT WORK

Let some one hold a watch and be prepared to make reports while you and perhaps your friends test yourselves in various ways.

COUNTING THE PULSE BEAT

Stand with your finger on your pulse at the wrist, and let him who holds the watch decide when the counting is to begin. He will say, "Get ready — now — begin." When he says that last word each child should, for himself, start to count the regular throb of the pulse which he feels under his finger. Let him keep on counting until, at the end of one minute, the timekeeper says, "Stop." You will then have your record.

If you are not excited, if you have not been exercising hard beforehand, if you have made no mistake in your counting, the number of beats which you feel will show

what your regular everyday pulse beat is. This is an important point gained. You have secured your standard for the standing position. You are ready for the next test.

Stand perfectly still, and, while the timekeeper follows the time again, open and shut your hand as fast and as hard as you can for an entire minute. Then once more count your pulse. You may find that it has gained a trifle. This will depend on the vigor with which you have worked the muscles of your hand. In any case, however, the muscles there are small and you will not get much of a result in the way of a more rapid beat.

He counts both Pulse Beat and Heart Beat

Turn, therefore, to the leg muscles of the body. Use them vigorously. Let each child run up one flight of stairs and back, and at once count the pulse again. You will find a marked change. From eighty or over at the start, you have probably increased the count by one half or more.

In addition to the above tests make one more. Even while the fingers of your left hand are feeling the pulse in your right wrist, place your right hand over your heart. You will discover that the pulse beat and the

heart beat occur at the same instant. And now, if you were not uncomfortably out of breath after the run up one flight, try two flights for a second test and notice that the number of beats has increased both at the wrist and at the heart. You have proved for yourself that the pulse beat may be depended on to show what the rate of the heart beat is.

The following table shows what such exercise did for a small class of children in a New York school. The letters of the alphabet stand for the names of the children.

TESTS SHOWING EFFECTS OF EXERCISE ON THE HEART BEAT PER MINUTE

	Normal Pulse	After Short, Quick Run
A	85	130
B	83	142
C	71	113
D	85	95
E	85	113
F	88	120
G	83	95
H	84	87
I	90	114
J	98	130
K	85	94
L	85	110
M	83	104
N	87	115

Each child was tested again within a minute after the run, and already the pulse was found to be beating more

slowly. This rapid return to the normal beat is the sign of a healthy heart.

At different times, on different days, test yourself in other ways. Count your pulse when you get up rested in the morning and when you go to bed tired at night. Count it before and after your cold bath in the morning. Count it before and after any variety of exercise that interests you. For example, run to school one morning, walk to school another morning, and compare the results of both with your standard. Compare the number of beats of the heart that has done hard work with those of the heart that has done light work, and learn to know what gives your heart the most exercise. Knowledge in this line will serve you well in deciding how to do the most for yourself in the shortest space of time. What you learn now will be applied in a later chapter.

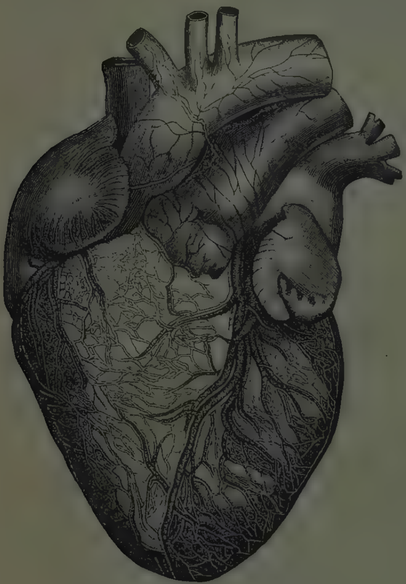
It would be quite worth while to keep your different records written down in a notebook of some sort for future reference. Already, however, you have learned that exercise makes the heart beat faster, and that the larger the muscles are, and the harder the work you give them to do, — running, for example, — the more exercise will you give the heart. You have also learned that the pulse may always be trusted to tell important facts about the action of the heart.

It is for this last reason that a doctor feels the pulse of his patient. By the regular or the irregular beat of

that pulse, by the way it hurries and by the way it drags, he is guided in his judgment as to what the condition of the patient is, and what ought to be done to help him. The heart, indeed, is one of the vital centers of our activities. We are well or ill, we live or die, through the work which it does or fails to do. Yet the ignorant are often misled by its action.

I am acquainted with a frail woman who supposed for years that she had heart trouble. She judged this by the fact that her heart beat hard and fast when she went upstairs, and that she lost breath easily when she went for a walk. Since she had heart trouble, as she thought, she decided that she must spare her heart as much as possible, — that she must do nothing that would set it into vigorous action. At last she became so anxious that she consulted a doctor, who assured her that her heart was thoroughly sound. "It is weak, of course," he said, "but how could it be otherwise? You say you have been afraid to take any exercise for twenty years." "Yes," she answered; "I wished to be on the safe side." He smiled in a queer way and said: "The safe side would have been to give your heart a little energetic exercise regularly. We need to train the heart just as we train any other muscle of the body. The simple trouble with your heart is that you have never given it a chance to get strong." Being a sensible woman, my friend began at once to follow the doctor's suggestion.

This, then, is one extreme to which a person may go. On the other hand we have the bicycle rider who overtaxes his heart so persistently as to injure it for life, and the boys who run long or hard races before their hearts have been trained for such violent exercise.



THE HEART AND ITS GREAT BLOOD VESSELS

We are well or ill, we live or die, by the work it does or fails to do

It seems that the heart is a strong, hollow muscle, about as large as the fist of the one for whom it works; and that even when it is not put under extra pressure it does more work than any other muscle in the body. It lies under the ribs, between the two halves of the lungs, and keeps up its beating from birth to death. It does, indeed, take more exercise than any other muscle; nevertheless, like every other muscle, additional exercise gives it strength, while lack of additional exercise leaves it weak.

In training this important muscle we must remember that most human beings have sound hearts that need to be treated in a reasonable way.

A neighbor of ours had taken no special exercise all winter, but when spring came he began abruptly by playing one set of tennis after another, without resting between the different sets. The end of it was that for many days and nights his heart kept up a rapid beating. For three weeks, indeed, it refused to come down to normal, and during this time the man dared take no exercise. He knew it would be unsafe.

THE CHAMPION PLAYER AT A CRITICAL MOMENT

If he had been careful to begin his tennis playing gradually that spring, increasing the amount from day to day, he would have done better work, would have spared his heart the overstrain, and would have saved himself those weeks of time when he could take no vigorous exercise whatever.

Watch those who race to catch a train or car. By the way they breathe you may know what the heart is doing. You will also be able to tell which of the running men and women have trained their hearts for sudden sprints of violent work, and which are pressing untrained hearts into unusual service. College students

often run by the mile across the town and out into the country. They are training not only the many muscles of their legs, but also the one muscle of the heart and their breathing apparatus. They wish to train their leg muscles, while at the same time they secure for themselves hearts and lungs that will be useful as long as their legs are able to keep up the running.

A doctor whom I know speaks of a man whom he himself trained. He says:

> When I took charge of him, the man could not run as far as from here to the door without fainting. He simply had a muscularly weak heart, excited by nervous shock and overwork, worry, deficient nutrition, and lack of sleep. I first discovered that there was no organic disease. Nothing but plain building up of muscle was needed. Then I went to work and started to build up that muscle. I would have him run a few steps and then lie down three minutes, then run a few steps more and lie down. I stood by, keeping track of his heart, not allowing him to do enough work to send it above one hundred and not letting him run again until it got back to normal. I kept him at it half an hour three times a day, from day to day increasing the doses; that is, I stuck to the medicine, but I gave very small doses, — doses suited to the strength of heart he then had. In three months that man could run eight miles an hour with great ease and comfort. Since then he has not known that he has a heart.

This doctor also speaks of a friend of his who ran up eight flights of stairs because of a fire, and so overstrained his heart that it has never been right since.

The point of all this is that when the heart has done what it comfortably can, and then has to do still more work and keep it up, it stretches too much for its own good. And worse still, if it is stretched badly enough, it stays stretched. This is part of the trouble with the overworked heart of the bicycle rider. Athletic trainers understand these facts thoroughly. It is therefore as much for the sake of the muscle of the heart as for the benefit of leg muscles that they insist that only those who have been trained for the contests shall be allowed to compete in athletic games. Otherwise the untrained person might faint in the midst of the sport, and this is not only harmful to himself but quite as unpleasant for those who are watching the contest.

The safe rule is to give the heart all the exercise it can comfortably take at one time, and to increase the amount as fast as its power increases.

As a rule, the actual size of the normal heart is proportioned to the work it has had to do. Animals kept in cages and captivity have been examined after death and their hearts have been seen to be smaller than the average heart of wild animals of the same species. In proportion to its size, the heart of a stag is about twice as large as that of a pig. The reason is plain. The stag lives by exercise which makes the heart work; the pig, however, in his slow life, seldom indulges in any unusual exercise.

Provided the matter is not overdone, nothing is better for heart development than exercise which calls for endurance. A quick run for a minute or a good jog trot lasting five minutes are as good as anything that can be devised. Run as you go to school in the morning; run on the way home at night. At each time run a little, then walk a little. Run only so much as you can quickly recover from. Indulge when you can in a good outdoor game. By your pulse beat and by the way you keep your breath or lose it, you will know what you may do. It is much better to begin with too little exercise than with too much, for you are going to make steady gain whatever your starting point is; and you gain most by going moderately at first.

Throughout his entire life, he who has a well-developed heart will also have more vigor, more power to endure, more courage than he otherwise would have.

CHAPTER X

DISCOVERIES BY A GRECIAN AND AN ENGLISHMAN

Certain facts about the connection between the heart beat and the pulse are so well known to-day that we are in danger of forgetting the debt we owe to two great men, — Galen the Greek, and Harvey the Englishman.

Before Galen was born in the year 130 A.D., learned men did indeed know that life stops when the heart stops beating; they knew that the blood of the body is contained in tubes; they saw that these tubes are largest near the heart and that they divide and continue to divide until each muscle and organ of the body is provided with its own unfailing blood supply. They also studied the tubes themselves, and saw that they are different enough to have two names.

Thus far in their investigations those ancients had learned well. But now we stumble on their strange error. "Veins," they said, "are filled with blood," — a correct statement. "But arteries," said they, "are filled with air," — an incorrect statement. The meaning of the word "artery" itself proclaims their mistaken belief, for in Greek it means nothing else than air tube. Although these ancient scientists made this mistake,

they described the structure of both veins and arteries much as we see them to-day. In course of time they even found, as we do, that the one great distinction of the veins is that they are supplied with numberless pockets on the inside lining of each tube throughout its entire length.

This was necessary, they said, because veins carried blood; whereas air tubes — arteries — needed no pockets, because they were filled with a substance called "vital spirits."

This belief of former scientists was perhaps not so strange as it seems to us. The truth is, they were led into error by the fact that after death the blood of the body settles in the veins, not in the arteries. That is, when a man is dead his veins are distended with blood, while his arteries stand up firm and round but quite empty. Those who investigated the subject came to their conclusion, therefore, in the most natural way. Then too, since the veins did certainly hold blood, they saw no reason why, during life, another set of tubes should also be filled with the same fluid. They did not appreciate the difference between the two kinds of blood which we know about.

But Galen the Greek was born. He practiced medicine in Rome, and was so great a student of the human body that, for fourteen hundred years afterwards, what he had said and written about health, and medicine, and

the structure of the body of man was taught and believed in every school of medicine in Europe. He was indeed the medical authority for the world.

Among other subjects he fastened his attention on these same arteries and veins, testing them and examining them in different ways. The result was that, step by step, he made progress. First he began to doubt what he had been taught. Next he doubted absolutely. But from doubt he moved on to a positive belief. When this belief was firm in his own mind he declared publicly that arteries as well as veins hold the blood of the living body.

The scientific world was amazed. It disbelieved. It said, "If you load up both sets of tubes with blood, how are the vital spirits to get round?" Galen replied by proof and by argument. He talked and he wrote until the other scientists of the time were as convinced as he. They finally accepted his belief that there are two kinds of blood: one kind in the veins, dark and rich and thick, which was supposed to nourish the heavier parts of the body; another in the arteries, light and bright and red, well mixed with vital spirits, which was supposed to do the lighter and the finer work for muscle and tissue.

He believed that both kinds of blood were found everywhere because both kinds were needed for the special help which each could give. He also believed

that all this blood moved back and forth, here and there, in haphazard fashion through the blood vessels, — that it shifted and drifted somewhat as the tides of the ocean move hither and thither.

As for the connection between the heart and the blood which we talk so much about, even Galen made no discovery about this. He believed that the heart expanded for the sake of drawing to itself breath from the lungs to be mixed with the blood, and that it contracted simply to get rid of such blood as it did not need.

Much that Galen taught continued to be believed until William Harvey made his great contribution to the knowledge of the world. In 1616 we find him lecturing in London. He was thirty-eight years old at the time. But when he died, at the age of seventy-nine, he had added such a volume of scientific facts to those which Galen had discovered, that during these three hundred years since then the two names have stood side by side on the honored roll of those who have transformed the beliefs of the human race.

Naturally, of course, Harvey began his work where Galen and his successors left off. He built on foundations which Galen had laid; but he was as independent of past beliefs as Galen himself had been. Whenever he had the opportunity, whether with men or animals, whether with those that were well or ill,

alive or dead, he studied their bodies and gave special attention to the action of the heart and to any connection which it might have with the blood supply.

In the case of wounded animals, at different times he laid his hand on the heart and noticed that with each throb the blood left the wound with a spurt, and he saw that blood which spurted in jets from a wound was always of the bright red kind.

Then too he came across wounds that bled in a different way. With them the blood simply poured out in a quiet, dark-purplish stream. In such cases there was no sudden increase of flow with the heart beat. He found that the same was true for wounds in man and beast alike; that is, bright blood came in jets while dark blood came in a quiet stream. Moreover, he saw that it was always true that when the heart beat slowly the pulse at the wrist was slow too.

These important observations, added to many experiments which he himself made, drew Harvey's thoughts more and more to questions about circulation. It then occurred to him that the heart might be a special machine for pumping bright-colored blood out into the arteries, and the thought of such a possibility was exciting even to himself.

Through yet other experiments and constant thought on the subject, his suspicions gradually changed to convictions. He became very sure that every pulse beat in

the artery at the wrist means that the heart has pumped a fresh supply of blood into the large artery, the aorta, which is joined directly to it, and that the elastic tubes have expanded throughout their entire length to make room for it. He knew, as we do, that the largest arteries are buried deeper in the body than the veins, and that only at certain spots do they come near enough to the surface to allow us to feel the effect of the heart beat. He noticed that there is never any throb in a vein, and this strengthened his conviction that no vein ever receives blood directly from the throbbing heart.

By traveling the road which he took we have come upon Harvey's first great discovery. I give it:

The heart pumps blood into the arteries.

The scientific world was even more excited over this announcement than it had been over Galen's discovery. But Harvey himself went quietly on with his investigations. He saw that the heart pumps by contracting and expanding; that the average human body holds about six quarts of blood; that the heart sends about half a tumblerful of blood into the aorta every time it contracts; and that, since the heart beats about seventy times a minute, an enormous quantity of blood must be squeezed out of it during each half hour.

He did some multiplying, as we ourselves might do just here, and decided that if the heart sends out over

one thousand tumblerfuls of blood every hour, and if the body holds no more than twenty-four tumblerfuls,—that is, six quarts,—the enormous supply must be explained somehow. Where did it all come from? This was Harvey's next great problem.

One sign after another led him to suspect that the veins might hold the explanation. He therefore tested veins and arteries too, as we ourselves may do.

A B C

POCKET VALVES IN THE VEINS

A shows a vein slit lengthwise and laid open; *B* shows a vein cut through lengthwise; *C* shows how a vein looks from the outside when its valves are filled with blood

Draw up your sleeve, swing your arm round your head once or twice, let it hang by your side for a minute, and you will notice that some of the blood vessels appear as dark lines under the skin. Stroke these lines down towards the wrist. They are veins, and the little bunches which stand out show where the valves have caught the blood. Remember that these valves are on the inside lining of every vein, and that they always open towards the heart. During the time, then, that the blood in the veins flows steadily towards the heart, the valves lie flat and smooth against the lining and you would not suspect their presence. But try to drive that blood away from the heart, and quickly every valve is so

filled that it stands out like a little pouch and helps block the passage of the blood backwards. The nature of the veins, therefore, helped Harvey on towards his next discovery.

While your left arm is still uncovered, press and squeeze it with your right hand, stroking towards the elbow to hasten the blood out of the veins. Now, as quickly as you can, tie a firm bandage about the arm just above the elbow. Tie this bandage as tight as you can without giving yourself pain. Within a few seconds notice how you feel, and notice the color of your hand. It remains pale and it grows cold.

A HANDKERCHIEF AND A STICK TO COMPRESS AN ARTERY

As the stick is turned the bandage is pulled tighter

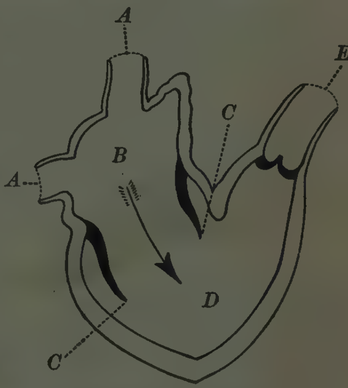
(After Tracy)

Arteries are buried deep, veins are near the surface. Your bandage is therefore checking the flow in both sets of blood vessels; and because no blood can get into the arm, the color of it stays about as when you tied the bandage. Above the elbow, however, you feel a throbbing, because the blood in the arteries is held back by the dam of the bandage. Loosen this bandage a little. You have now lifted the pressure from the arteries, and blood hurries

towards the hand. But the veins are under pressure still; notice what is happening. Blood is entering through the arteries; it cannot escape through the veins because of the pressure of the bandage. As a result the hand grows red and swollen from its unusual supply. Release the bandage entirely, and in almost no time those veins have relieved themselves. Blood is once more streaming upwards.

Such experiments as these and others led Harvey to his second announcement. He declared to his astonished friends that:

The heart receives its entire blood supply from the veins.



THE RIGHT AURICLE AND VENTRICLE

A, vein that brings blood to the auricle; *B*, auricle; *C*, valves that are forced open by the blood as it passes into the ventricle; *D*, ventricle; *E*, tube through which blood goes to the lungs to be purified

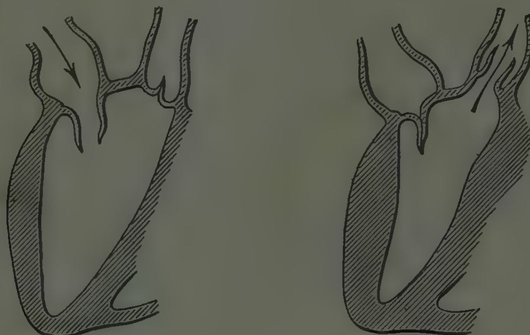
To complete this account, turn to the heart again and remember the following facts about it:

1. The heart is a powerful muscle. It does its work by contracting and relaxing.

2. The heart is made up of two halves; and the wall of muscle between these separate halves is so firmly closed that after birth, and after the heart is in good working order, not a drop of

blood ever passes through it from one side to the other.

3. Each half of the heart has two divisions, the smaller called the auricle, the larger called the ventricle.



Two Views of the same Ventricle to show the Valves

On the left blood enters; on the right the ventricle contracts and forces the blood onward

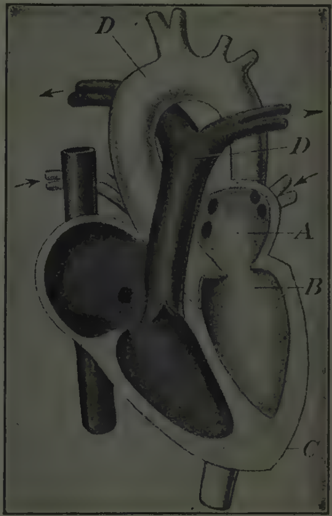
4. Each auricle and each ventricle has its own opening, its own tube for blood, and its own valves to prevent the blood from running the wrong way.

5. The auricle in each half of the heart always receives the blood and sends it into its own ventricle.

6. Each ventricle receives blood from its own auricle and sends it off to its own district of the body.

At this point we reach a most interesting fact about this process of circulation; yet it may be given in a few

easy words. One side of the heart receives blood from the body and sends it to the lungs; the other side of the heart receives blood from the lungs and sends it to the body. We see, then, that one side always deals with pure blood alone, for all that comes to it is fresh from the lungs and is sent onward in the same condition; while the other side deals with impure blood alone, for all that comes to it is from the body after it has been used, and it goes onward to the lungs in that condition to be purified.



THE FOUR CAVITIES OF THE HEART

A, auricle; *B*, ventricle; *C*, outline of the heart; *D*, *D*, blood vessels

The dark side receives impure blood from the body and sends it to the lungs; the light side receives pure blood from the lungs and sends it to the body

Thus the entire blood supply of the body, on each journey round, passes through both sides of the heart and through the lungs before it goes back to nourish the body. This was Harvey's great discovery about the circulation of the blood. Even for him, however, there was a mystery which the microscope alone could solve. The next chapter will speak about it.

CHAPTER XI

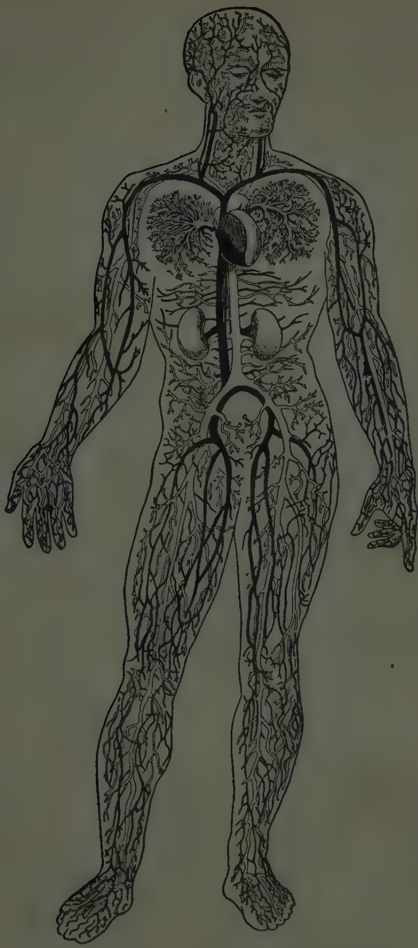
TO THE CAPILLARIES AND BACK

To complete the proof about blood which makes its regular journey from the heart round the body and back again, scientists have the testimony of the blood itself. They have taken a syringe as slender as a needle, and by its use have pricked some harmless chemical into a vein on one side of the body of a horse or of a man. They have then examined blood drop by drop from the corresponding vein on the opposite side of the body until the same chemical has appeared there.

By comparing the time when the substance was put in, with the time when they find it again, they know how long it takes for blood to make the entire circuit of the body. The following table gives results:

For a horse, twenty-five seconds.
For a full-grown man, twenty-three seconds.
For a child of fourteen, eighteen seconds.
For a child of three, fifteen seconds.

Evidently each set of tubes and each heart does its work more or less rapidly, according to the distance which the blood has to travel. But for each one of us the road which the blood takes is ever the same. The

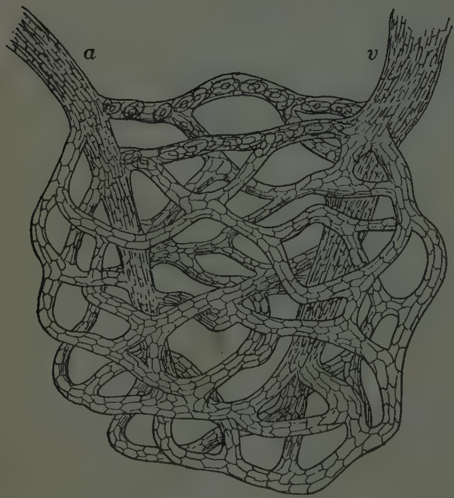


Veins and Arteries

Black tubes represent veins through which impure blood goes to the right side of the heart from all parts of the body; light-colored tubes represent arteries through which pure blood from the left side of the heart goes to all parts of the body. Notice that the large tubes of each kind lie near one another

steps of its progress are veins, heart, lungs, heart, arteries, veins. When the chemical is found it is on its return trip to the heart.

Even this experiment does not, however, show how the blood gets across from the arteries to the veins for its journey back. Harvey himself was not sure about this, for he had no microscope. But when the microscope came with its revelations, doubts and questions were cleared away. Instead of blood spread about everywhere among the muscles under the skin between the arteries and the veins, there was found to be no blood anywhere outside of the tubes. Moreover, each drop of blood was found to be a part of the ceaseless stream which flows through tubes that divide and subdivide until they are too small for the unaided eye to see, then unite and continue to unite until they are again large enough to be seen.



UNION OF ARTERIES AND VEINS

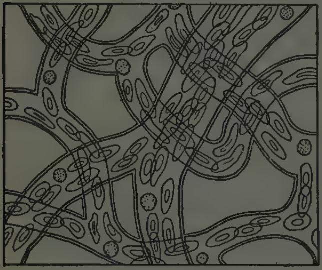
a, artery; *v*, vein. A network of capillaries joins them

From the heart and back again, all the blood of the body is seen to be closely inclosed in these larger and smaller tubes. This is what the microscope shows. And the sight of its progress through the tubes must have thrilled those who watched it for the first time.

One early scientist used his crude microscope on the tail of a tadpole. He had already discovered the corpuscles of the blood, which we shall study soon; and he saw these separate "blood globules," as he called them, moving after each other in single file through the narrowest of the tubes. Sometimes they moved in faster, sometimes in slower, procession; and sometimes they were even bent over and pressed out of shape as they were forced through the narrowest places. He grew enthusiastic over what he saw, and wrote a glowing account of it over two hundred years ago:

> The motion of the blood in these tadpoles exceeds all the rest of small animals and fish I have ever seen; nay this pleasure has ofttimes been so recreating to me that I do not believe that all the pleasures of fountains and waterworks, either natural or made by art, could have pleased my sight so well. And now at last I spied a small artery, that notwithstanding it is so small that, I judge, but one small red globule of blood could pass through it, . . . yet, what was most remarkable was to see the manifold small arteries that came forth from the great one, and which were spread into several branches, and turning, came into one again, and were reunited, that at last they did pour out the blood again into the great vein; this last was a sight that would amaze any eye that was greedy of knowledge.

From what he saw, and from what the microscope may show us, too, we find it easy to understand that every slash and wound of the body cuts through a mesh of lace work more delicate than the finest lace ever made by the hand of man; we see that each thread of this lace is a tube doing faithful duty in carrying blood to remote regions of the body, and that everywhere there is blood simply because everywhere there is the same intricate interlacing of these marvelous tubes. Their name *capillary* means "hairlike." Yet the microscope shows how much smaller they sometimes are than any human hair, however soft and fine.

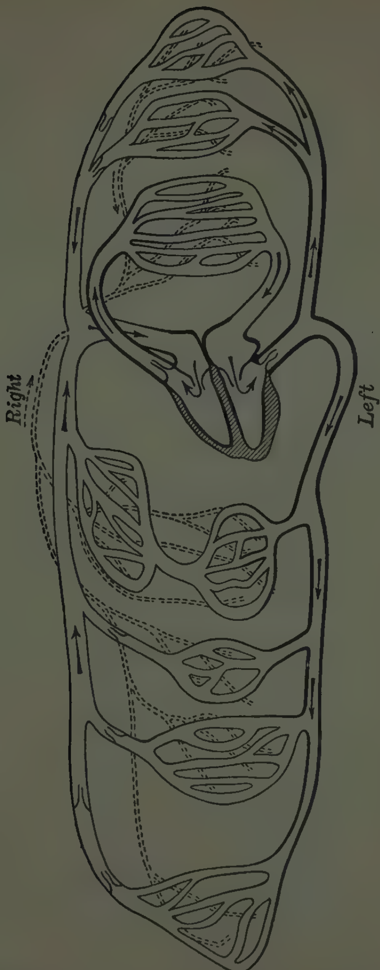


CORPUSCLES IN THE CAPILLARIES OF A FROG'S FOOT

By careful calculation it has been found that fifteen hundred capillaries would have to be laid side by side to cover a surface an inch wide.

As a rule, the amount of blood which is inclosed in this system of tubes which includes heart, arteries, capillaries, and veins, is about one thirteenth the weight of the person. We may then calculate our own supply of blood by our own weight.

So much blood does it take to keep the blood vessels and the heart as full as they need to be. The truth, however, is that being elastic they could at any time



THE HEART WITH ITS SYSTEM OF TUBES

Arrows show the direction in which the blood flows. Follow its course from the body into the right side of the heart; from there to the lungs; thence to the left side of the heart and out to the body again. Each cluster of tubes shows in a rough way where some organ of the body is located

hold more than is now in them; and that at any time also they could get along very well with rather less than they now carry.

In former times men sometimes died for no other reason than that they lost so much blood from wounds of one sort or another that the sides of veins and capillaries collapsed, and the heart had to stop work because there was too little blood left in the body to be pumped round. It was therefore a great discovery when men found that the heart is quite as willing to pump warm salt water out into arteries and capillaries as to send warm blood to the same places. Nowadays, therefore, when a man is losing much blood through an operation or through an accidental wound, a surgeon, working as fast as he can, pumps salt water into the veins to replace the blood. This water is carried on round the circuit as swiftly as if it were the richest blood, the pumping of the heart continues, and a life is saved.

No one dreams for a moment that salt water can take the place of blood day in and day out for many days continuously, but all know that it may be depended on for a season. It keeps the veins filled and the heart in action while the proper sort of blood is being manufactured by the body itself.

In a way we might suppose that, whether water is mixed with it or not, the blood of the body is spread out in equal quantities everywhere, being regulated by the

size of the tubes which carry it here and there. The truth is, however, that standing over the blood supply is the never-failing fact that exercise regulates the amount which goes here and there; that is, what we do always settles the question as to where the blood shall go. For the normal, healthy person this law never varies. It may be stated in a few words: *That part of the body which is exercised the most gets the most blood; that part which is exercised the least gets the least blood.*

The next chapter will show what it means to the body when this law is remembered or forgotten, and what the nature of the blood is, that it should be so greatly needed here and there.

CHAPTER XII

BLOOD INSIDE AND OUTSIDE THE TUBES

When you take your morning bath why do you use cold water, a rough wash cloth, and a towel rougher yet? Why do you work fast and rub hard? For the simple reason that you wish to draw more blood to your skin capillaries, and the pink color shows how well you have succeeded.

I have a frail friend with blood vessels so lifeless that her skin is about as pale after exercise as before it. The other day, however, she felt encouraged. "An unusual thing happened this morning," she said; "I managed to get some color into my chest when I rubbed it. I have n't been able to do that before for years." She knew that active movement of the blood through the blood vessels is one of the important advantages of exercise. To understand this more definitely, examine the blood itself. Drops drawn from your own body will meet the need perfectly. To secure them, tie a string round the last joint of a finger on your left hand. This leaves your right hand free for whatever it needs to do. Bend the tied finger over to increase the pressure of the blood in its capillaries. Take the finest needle you have, hold it in a candle or a

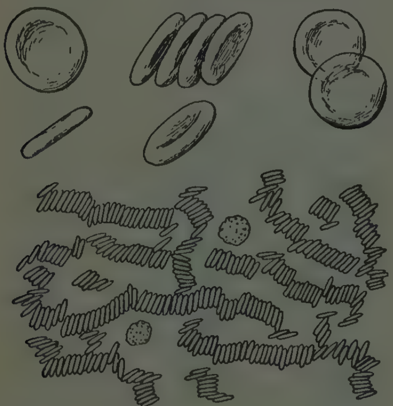
lamp flame for a moment to rid it of microbes, then stick the point of it quickly into the dark red end of the finger. So much blood has been held back that you will barely feel the prick. Nevertheless, a good-sized drop will ooze through and be ready for immediate use.

To get this blood you have torn open the sides of several capillaries smaller than the needle; but they will repair themselves in time, and just at present you have more need of that red drop outside of your body than inside of it. Have a piece of clean glass ready and jostle the drop of blood down upon it. Raise the glass, hold it over something white, and notice the color. You will see that it has a yellow tinge.

Prepared to draw a Drop of Blood

Now break through a few more capillaries with your needle; draw another drop of blood; put it also on the glass, and leave it there for five or six minutes. Look at it now and you will find that it has turned itself into jelly. Set a tumbler over it and let it remain there undisturbed for half an hour or so. At the end of that time you will see a bit of red substance floating in a small drop of liquid which is almost colorless.

Look back at the finger you pricked, and, if you did not wipe it off clean after you pricked it last, you will see that there, too, a remnant of the blood has hardened round the edges of the tiny wound. This will remind you of the statement so often made, that the best healer for a wound is the blood which oozes through it. We clean a wound thoroughly, we pull the edges towards each other, we even sew them together sometimes, and the blood which continues to ooze from the capillaries hardens on the edges of the wound. We are careful to leave it there undisturbed, for we know that it closes the break better than any kind of plaster, and that the work of knitting these separated edges together goes on best under the crust of hardening blood.



CORPUSCLES SEEN BY THE AID OF A MICROSCOPE

A few red ones are highly magnified. Those that are less magnified show how corpuscles stick together after blood is drawn from the body. Two white corpuscles are given

If we could add the use of a good microscope to our experiments, and if we knew just how to use it for such close investigations, we should draw a third drop of blood, put it under the microscope, and learn a number of startling facts about its composition. We should then

recognize it as a liquid with multitudes of small red and white objects floating in it. Blood is indeed a mixture of three things:

1. Red objects called red corpuscles. There are something like two hundred million of these in each drop of healthy blood. Imagine then their size! Each is round and flat and has a concave center. Its shape is such as you would get by taking a wax marble and mashing it between the thumb and finger. Pressed in this way, the center is thinner than the edges. So is it with every red corpuscle. Nevertheless, these microscopic disks are the important oxygen carriers of the body, and they never leave the blood tubes unless these tubes themselves are crushed or cut or forced to leak through accident or disease.

RED AND WHITE CORPUSCLES
Four different shapes and four positions taken by the same white corpuscle

2. The liquid part called plasma. This is quite transparent and almost colorless. A little over one half of each quart of blood is plasma; the rest is the corpuscles.

3. Colorless objects called white corpuscles. Of these there are only about six hundred thousand to each drop of blood, although the number varies greatly from time to time. They are specks of jelly-like substance that change their shape constantly. They not only travel with the other corpuscles in the plasma, but they also work their way through the walls of the capillaries and wander here and there in the body. They destroy intruding microbes when they find them, and help more than any other part of the blood in healing a wound. Much more is told about these white corpuscles in the thirteenth chapter of *Control of Body and Mind.*

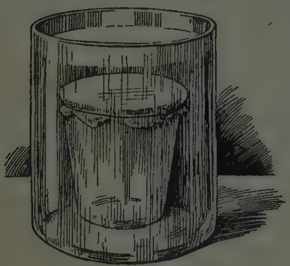
Plasma, red corpuscles, and white corpuscles tell us all that the microscope shows when we use it for the study of blood. But a chemist will take the same blood, will analyze it in his laboratory, and will prove that it is made up of many different substances of which we have not so much as heard the names, — substances needed, however, for the work which each separate part of the body is doing. He will tell us that within this blood is all that is needed for the manufacture of bone and muscle, hair and tendon, tears and fat and finger nails; that it is the source of supply for all that lies under the cover of the skin, the storehouse for more treasures than we have even dreamed about; and that it is easy to enrich or to impoverish the blood by our treatment of the body.

This then is the blood itself,—the surprising red liquid which some of us are so afraid to touch, the marvelous red liquid which determines our health for us. While it moves through our branching blood vessels we live; when it stops moving we die; and in proportion as it is well supplied or unsupplied with that which each part of the body calls for, are we well or ill. It is this last fact indeed which should make the study of these pages of priceless value to us, for through the knowledge which we gain of physiology and hygiene we shall finally learn how to keep the body supplied with the kind of blood which it must have in order to do its best work for us.

CHAPTER XIII

EXCHANGES ALONG THE TUBES

Even a careless thinker will see that however intricate the lace work of capillaries is, and however closely these small tubes are intertwined with tissues of muscle and gland, still the blood within the tubes is useless to the body unless it can be brought into direct contact with the muscle and gland tissues themselves.



ONE GLASS WITHIN THE OTHER

The smaller glass holds fresh water, the larger holds water and salt

An experiment will make the situation plain and will show what the outcome of it is.

Get from the butcher a piece of fresh animal membrane, — the bladder will do. Fill a small glass with fresh water, tie the membrane tightly over it, set the glass into a much larger one filled with salted water, letting the water cover it, and leave the two tumblers together over night. In the morning take the smaller from the larger, unfasten the membrane, and taste the water which was fresh and sweet the night before. You will find that it is now distinctly salt. Taste

the water in the larger tumbler. You will find that it has grown fresher than when you left it.

In this exchange the salt in the liquid has acted according to a universal law. Salt is indeed one of the many substances which always pass easily back and forth through any moist animal membrane.

Put sugar into one liquid and soda into another; let a membrane be stretched between them, and before long you will have two liquids that have become strangely alike. The different substances in the liquids have changed places through the membrane.

Even gases are subject to the same law. Men who know how to handle such things can put oxygen in one tube and carbon dioxide in another. They can then arrange to separate the gases by a piece of animal membrane stretched between the tubes, and they discover that the two gases refuse to stay apart. Indeed, so much of each finds its way through the partition that soon there is a mixture of the two on either side of the membrane.

Experiments such as these answer the query as to how the body gets what it needs from the blood. Everywhere it is the animal membrane of the tubes themselves which separates the blood within the tubes from a certain other liquid which lies close about them on the outside.

However small and however thin walled the blood vessels may be, there is always this lymph bathing the

outside like a sort of colorless sap in the body, and making its exchanges with the contents of the liquid within the capillaries. Moreover, this lymph which soaks slowly but constantly through every tissue of the body is laden with carbon dioxide which it has received from the tissues of the body. The blood is rich in oxygen, and it is separated from the lymph only by the walls of the capillaries. In view of this, what could be more natural than the thing which comes to pass? These gases in the lymph and in the blood change places with each other as promptly as do the liquid materials which are also in the lymph and in the blood.

It is evident, then, that the lymph is as important to us as is the blood itself. In fact, the two must always travel side by side. They are indispensable to each other. Without the one the other is useless. Three statements will show how close the relation is:

1. Blood in the arteries is the result of the food we eat and of the air we breathe. It contains every supply that any part of the body needs for nourishment, for strength, and for growth.

2. Blood in the veins is what is left after the lymph has taken from it the oxygen and other nourishment which the body needs, and given in exchange the carbon dioxide and other waste which must be carried off. In other words, venous blood is rich in waste from the tissues and poor in nourishment for the tissues.

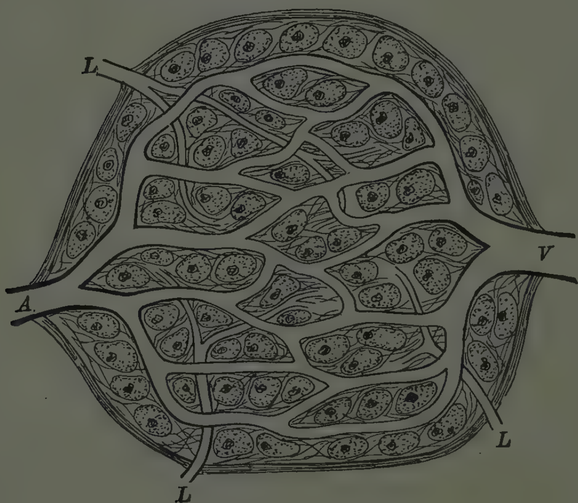
3. Lymph is made up of rich, nourishing plasma from the blood, on its way to the tissues, and of waste material from the body, which will soon pass into the capillaries, be carried onward in the veins, and be disposed of as we shall learn hereafter. Lymph is also the highroad to the blood for many substances that are being manufactured by the different organs of the body. These manufactured articles must find their way into the blood, for only through circulation will they ever be able to reach their destination.

The origin of the lymphatic tubes is strangely interesting for the simple reason that it is so very indefinite. Each seems to begin about as irregularly as a stream gathers water in a swamp.

As we know, blood vessels are a closed system of tubes with a stream of blood sweeping through them endlessly, —going ever round and round, from heart back to heart again. In this great system not even the smallest tube in the remotest region of the body is left with an open mouth. The lymphatic system, however, works on quite a different basis. Here the vast multitudes of the smallest tubes seem to be really little more than open mouths into which liquid is gradually making its way. Bear this in mind while the facts are given as definite statements:

1. Each blood vessel of the body makes its way through a mesh work of tissues.

2. Everywhere among these intertwined tissues there is a colorless liquid called lymph. The capillaries of the blood are surrounded by this lymph even as grass and weeds are surrounded by water in a swamp. Lymph looks like plasma of the blood.



A Cluster of Tubes

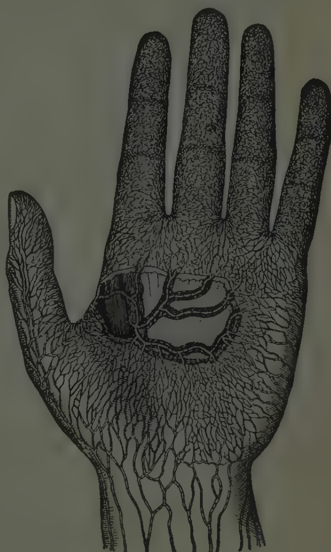
Look for those with open mouths: *A*, artery; *V*, vein; *L*, *L*, *L*, lymphatics

3. Lymph and plasma are constantly making exchanges through the walls of the tubes of the blood vessels.

4. Plasma receives from the lymph all that the body is through with — all that should go on in the blood and be disposed of elsewhere.

5. Lymph receives from the plasma all the nourishment which the tissues need.

6. Opening away from the loose fibers through which the blood vessels run, and in which all this exchange is going on, there are other tubes about as small as the capillaries; and into the open mouths of these tubes the lymph from the tissues gradually makes its way.



LYMPHATICS OF THE HAND

Smaller tubes lie near the surface, larger ones lie deeper

7. Vigorous exercise hastens the flow of lymph no less than of blood, and the tissues are benefited thereby.

8. From start to finish the lymphatic tubes progress from smaller to larger, as do those of the veins. They are also provided with inside pockets quite like those of the veins. These pocket valves keep the lymph from moving backwards and help to send it constantly onward, that it may at last mingle with the great stream of blood that goes to the heart.

9. This progress from smaller to larger tubes continues until all the lymph of the body finds its way through two large lymph tubes, one on each side of the neck. These empty into two large veins, and thenceforward lymph and blood go on their way together to the heart. The lymph, with all it has gathered, has now entered the circulatory system, and thus the contribution from the many different organs of the body will be distributed by means of the blood. The movement of this fluid continues during life, for the lymph vessels and lymph spaces can never be empty so long as the organs of the body are at work.

VEINS AND LYMPH TUBES

The lymph tubes are white and are seen to empty into the large veins

A special point to remember is that blood vessels and the tissues are as much better off when fresh lymph surrounds them, as are fish when they are in fresh water.

CHAPTER XIV

ALCOHOL AND CIRCULATION

A man is sometimes so sensitive about the dull red end of his nose that he is ready to welcome almost any device which may rid him of it. Perhaps he knows and

Pricking the Capillaries

By electricity through the point of a needle many capillaries are destroyed; after that the man is cured of his red nose

(Copied from the *Literary Digest*)

perhaps he does not know that the reason for the color is the condition of his capillaries. Each smallest tube in the special spot is indeed overcharged with blood; and

in so far as a nose is bright red or dull red are we ourselves able to judge as to whether or not the capillaries are particularly distended just there.

Red eyelids and a pink nose tell plain facts about the state of the capillaries in those particular regions. But in the matter of general health, the mere fact that a man has a red nose signifies very little. Many a hearty sea captain has carried such a nose with him through half a century of life. He has lived to be eighty years old or older, and the shade of his sunburned nose has made him neither more nor less healthy than he otherwise would have been.

Sometimes, however, the color of a man's nose is a sign of general internal conditions. It may show that the capillaries throughout his body are loaded with slow-moving blood; and this condition of the capillaries throws a flood of light on the sort of work which the heart itself is doing.

Judging by facts which we have already learned, three points are clear:

1. Slow-moving blood is more impure than that which moves faster; for this reason such blood is always a disadvantage to any part of the body in which it tarries.

2. The mere fact that blood is moving fast shows that impurities are being hastened out of the way and that fresh material is being supplied to lymph and tissue.

3. The blood vessels must always be in a healthy, vigorous, elastic condition if the best exchanges are to be made through their walls.

In view of these statements we are ready to understand a set of scientific discoveries about circulation which have been made during the past few years. It appears that for many previous years educated doctors and ignorant men alike were united in the conviction that alcohol was a genuine help to the vigor of the circulation. Thousands of men thought they had proved this by personal experience. At different times, and in different places, they had taken alcohol in large doses or in small doses as they chose, and after the drinking they had tested their hearts and knew by the count of the pulse that the number of heart beats had increased. They felt the blood bounding faster through their veins, and it was most natural for them to believe that the alcohol which they had taken had strengthened the heart, even as food strengthens the body.

In time, however, an instrument was invented which measured the strength of each heart beat. This instrument is in wide use to-day, because doctors find that they can judge in a general way as to whether a man is well or not by the vigor or the languor with which his heart does its work.

And now for the surprise which overtook doctors and scientists alike. They took alcohol themselves;

they gave it to their friends and their patients; they studied the heart and found that its throbs had increased in number. But when they also used the apparatus — the sphygmograph — they were surprised to see that the heart was not putting as much power into each stroke now as it did before the alcohol was taken.

THE SPHYGMOGRAPH ON A WRIST AND THE RECORD IT IS MAKING

Over and over again the tests were made, and always with the same result. Each trial showed that although the heart was now pumping faster than usual, it was nevertheless doing its work with less vigor. It was using less force for the increased number of strokes than it used for the smaller number made before alcohol had been added to the blood.

Testimony of this sort put a new color on the practice of using alcohol when the heart needs to be strengthened.

Doctors in every land had to yield to the evidence of their senses. They had to believe that, instead of giving strength, alcohol actually robs the heart of a part of the strength which it had before the alcohol was taken.

This was a difficult doctrine to accept, and question and investigation continued to pursue each other in quick succession until at last there was no further doubt about it. To-day the facts of the case are accepted by all persons except those who are not up to date in the matter. I give a few of the most important points:

1. Healthy tubes that carry blood are elastic. They stretch out when blood is pumped into them by the heart, and they contract firmly again as they send the blood onward.

2. The first effect of alcohol in the body is to paralyze in a very slight way every tube that has anything to do with carrying blood hither and thither.

3. Because the tubes are slightly paralyzed they are more relaxed than formerly. They contract less. They therefore offer less resistance to the blood that is pumped into them. After they are full they stay relaxed, and do not have the elastic power to pull themselves firmly into shape again.

4. The heart is also slightly paralyzed by the alcohol. Still those countless relaxed tubes offer so

little resistance that the heart pumps the blood into them with less effort than formerly, and, as a result, contracts more frequently.

Thus far, however, no harm appears. The capillaries are full of blood; the man feels the warmer for it, and his heart is beating a trifle faster than usual. That is all. But now begins the chapter of damages and calamities.

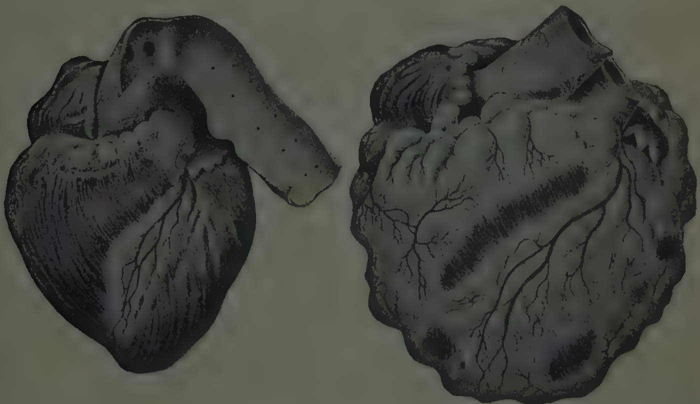
During the time that the heart itself is weakened, it cannot put force enough into each stroke to drive the blood on in spite of the relaxed state of the walls of the tubes. Various results are now inevitable. Blood moves more slowly through the tubes; it is slow in carrying away broken-down tissue from the lymph; it is slow in bringing fresh nourishment for the rebuilding of the tissues.

In the meantime, if alcohol continues to be taken, the capillaries may be kept stretched so long as to lose all power to contract. If this is persisted in, the walls themselves end by becoming thicker and stiffer. The work of exchange which should go on at a rapid pace through them is thus interfered with, and the health of the drinker suffers in numerous ways.

This is no fancy picture. It is simply the history of circulation in such persons as are ignorant enough to be willing to rob themselves of the work which their blood and their blood vessels should do for them.

The most alarming side of the affair, however, is in connection with what happens to the heart. Because

this tireless pump is weaker than it was, it also becomes stretched; and as it cannot do full work, it lacks the exercise which would keep it in vigorous health. It grows flabby, as does an unused arm. Fat gathers not only between the fibers but also within the separate fibers. In this latter case fat takes the place of tissue



Two Hearts Side by Side

On the left the heart is normal, on the right it is enlarged and weakened by fat

(Copied from *Alcohol and the Human Body*, by Horsley and Sturge)

itself, and then occurs what is called fatty degeneration of the heart, — a most serious condition. For a heart of this sort is too weak to send blood onward as rapidly as it should go. This means that circulation throughout the entire body is hindered, and that each great organ suffers for lack of what it should get through fresh supplies of blood. Evidently then he who owns a fatty heart,

weakened from any cause, is far less sure of continued life than he might have been. Since he secured this condition through ignorance, he is not to blame. But sad as is the fact, ignorance never saves men from the results of their ignorance.

Why do surgeons dread to do anything for the man who uses alcohol? Because they know only too well that the power of his heart and the elasticity of his arteries have been reduced. They are afraid that his heart may not rally after they have done what cutting is necessary. In writing of this danger, Sir Frederick Treves says:

> Having spent the greater part of my life in operating, I can assure you that there are some patients that I don't mind operating upon and some that I do; but the person of all others that I dread to see enter the operating theater is the drinker. He is the most dangerous feature in connection with the surgical life.

It is because of this constant state of relaxed capillaries that the nose of the drinker stays red. In his case the nose is frequently a reliable sign of internal conditions.

CHAPTER XV

AS WE GROW BREATHLESS

If you were ever thoroughly out of breath, recall the sensations you had at the time. Perhaps you were trying to catch a train; perhaps you were running in a relay race. In either case you felt that you must reach the goal at all hazards, and you ran as you had never run before.

RUNNING AS FAST AS POSSIBLE

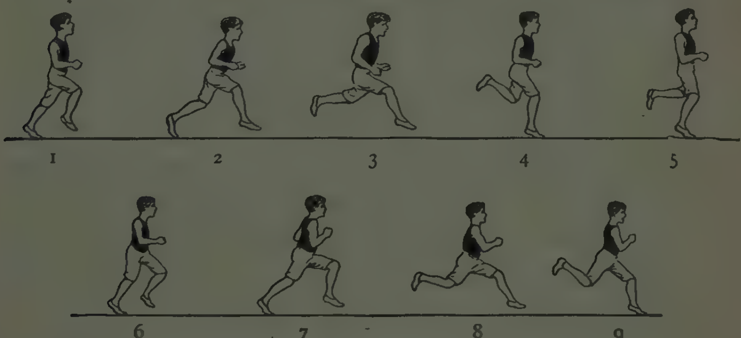
But think of the discomfort of it! Since your legs were young and strong you thought nothing about your muscles, but simply used them hard. You ran fast. Your breath came and went freely, and during the first few moments you drew deep, long breaths of equal length. Soon, however, you found that each breath was shorter than the last; also that they came and went in quicker succession. You began to be uncomfortable. There was a tight feeling within you, as if an iron band were closing itself about

your chest; as if it prevented you from expanding your lungs to their full size. You wondered how much longer you could keep it up.

Soon discomfort changed to real distress. Your breath came and went in jerks. Your legs still worked hard and you were running as fast as ever, but there was a pounding in your temples, a buzzing in your ears, your eyesight seemed to fail; you barely noticed what you passed in your flight, everything grew blurred. You did not see the people who stared at you. You did not know that you were pale and that we who watched you longed to scream out that you must stop running at once. You kept on, and when you reached the goal your friends praised you for your pluck. But you had no power to thank them. You were still breathing in short gasps. This kept on for several minutes. When at last you could breathe comfortably again, perhaps some one asked you if your legs did n't get tired when you ran so fast. And probably you said: "My legs were in good shape. I could have run longer yet, so far as they were concerned. The trouble was, I could n't get breath enough. I was nearly suffocated." In other words, you had gone through a genuine siege of breathlessness, and nothing is much more uncomfortable.

But why were you breathless? To answer the question, follow once more the condition of muscle and bone, tendon and heart, lungs and blood vessels, while you

were running. Think for a moment of your unelastic tendons as they stayed firmly gripped to their bone attachments. Remember how each one of multitudes of muscles, large and small, shortened and lengthened as, by means of their tendons, they pulled those leg bones of yours up and down and kept them at work. Remember that neither arms nor head nor any other



NINE VIEWS OF THE SAME MAN AS HE RAN

A different set of muscles is at work in each position, so that altogether many muscles are used in running

(After Schmidt)

part of your body was quiet as you ran, but that every muscle seemed to work hard in keeping time and step with the movement of the legs. Remember that such violent action as this means that changes are going on in the substance of the living tissue which is exercised; that these changes involve the giving off of unusual quantities of carbon dioxide; that oxygen is needed by

the working fibers, and that in order to supply the oxygen and to carry off the carbon dioxide fresh streams of blood must be hastened to the active muscles with ever-increasing speed. The most immediate, imperative need of each working fiber is to get rid of the excess of carbon dioxide.

There are then three steps to such a condition of breathlessness:

1. Exercise violent enough to compel the fibers of the muscles to produce unusual quantities of carbon dioxide. As this gas is produced oxygen is demanded by the fibers. It is indeed as if they themselves were breathing.

2. The activity of the chest walls as they expel the carbon dioxide from the air sacs of the lungs and replace it with air containing oxygen.

3. The rapid work of the heart as it receives larger amounts of impure blood than usual through the veins and sends arterial blood to the tissues to carry oxygen and to bring away carbon dioxide. To a large extent it is this forced work of the heart that explains the feeling of breathlessness.

We were speaking of this matter the other day, and my friend, who teaches physiology, said:

> People used to say that a man was breathless because there was more carbon dioxide in his blood than he could expel through his lungs. But we know better now. We know that it is n't so much the carbon

dioxide — although of course that has to be driven off — as it is the overtaxed heart that makes us breathless.

Boys come to me for examination; and when they complain about their lungs, and say that they get out of breath easily, I know that in all probability most of the difficulty lies elsewhere. The truth is, the heart gets tired from overwork, just as the biceps does, and it is quite as possible to strengthen the heart by training as to strengthen the biceps. At first I put the boys on easy exercises that tax the heart but little; then day by day I give what is harder, until, almost before they know it, those boys have developed hearts that are strong enough to do good hard work without making them breathless.

The recognized fact is that we grow breathless in proportion to the force which we put into any exercise in a given length of time; that is, the faster we do the same thing, the more quickly will breathlessness overtake us. It is easy, therefore, to understand an opposite condition, and to believe that the quieter we are, the less oxygen will the tissues use and the less carbon dioxide will the body have to get rid of.

The following figures show the amounts of carbon dioxide which a man gives off while sleeping, sitting, or running for a given length of time:

While asleep	.035 gram
While sitting	.060 "
While running	.165 "

Men have killed animals after a long hunt, and have found the blood of the arteries so changed in color that it looked like blood from the veins. It was dark and

impure because it held an oversupply of carbon dioxide and had lost most of the oxygen which would have given the animal life. From the veins the carbon dioxide had gone through the heart and through the lungs out into the arteries.

When we are breathless most of the trouble is due to the fact that the heart is overtaxed by the large quantity of blood sent to it from the hard-working muscles to be forwarded to the lungs to be purified of its carbon dioxide, while at the same time the lungs are also overtaxed by their unusual work.

Those who train for athletic sports learn to keep the balance of the gases in their blood. They know how to manage their running and the work of heart and lungs in such a way that neither will be overtaxed until the end is near. They are willing to be breathless at the very last because they are soon to stop running and catch their breath again. But to get breathless at the beginning of the race means defeat.

The same is true in horse racing. No good jockey lets his horse get out of breath until the last part of the race. At that time, however, the horse is urged to work the muscles of his legs as hard and fast as possible. It is safe to do this now, for as soon as he reaches the goal his muscles will stop producing such quantities of carbon dioxide and his heart will cease to be overtaxed by its work of pumping this impure blood to the lungs to be purified.

No two horses and no two men or boys are alike in this. Each has his own rate of producing carbon dioxide and of expelling it. Each must therefore discover for himself what the power of his heart is, and learn to increase it. Through practice a man is finally able to adopt a pace in which his heart and his lungs work in unison, — a pace which he can therefore keep up without overtaxing his heart and without overturning the balance of the gases in his body. He makes the discovery that exercise of the large muscles of the body and of the legs calls for much more oxygen in much less time than does exercise of the smaller muscles, and that both heart and lungs need to be trained in relation to each other before he can expect to do hard or rapid work without getting out of breath.

CHAPTER XVI

WHERE BLOOD CHANGES COLOR

AS SHE BREATHES SHE FEELS THE MOVEMENT

Place one hand lightly on your chest; place the other on your back between the shoulder blades; inhale slowly until your lungs are full, then exhale slowly until they seem empty. While you do this notice that the breastbone rises, and that the front and rear walls of your chest are forced gradually farther apart.

While you take another long breath and send it out again stand with your hands resting lightly on each side of the body just over your lower ribs. Notice that it is expansion sideways this time; you also see that the capacity of your chest has increased greatly.

Take a tape measure and get the girth of your chest after you have exhaled all you can, and again after you have drawn in as large a supply of air as your lungs will hold. Learn from these tests that the size of your chest can be increased and diminished at will, and that its size can be increased permanently by frequent exercise of this kind. To prove this in your own case, measure your chest to-day; then for two months take fifteen deep, full breaths three times a day. With each breath expand your lungs as fully as you can without really straining them. At the end of the two months measure yourself again and you will find that your chest measure has increased. From this you have the right to conclude that your lungs also are larger.

Measured by the Doctor

With his Chest Expanded

We often talk of the lungs as if they were a pair of big bags tucked in under the ribs somewhere, waiting to swell out or to sink in according as we use them. In a way the notion of the bag is rather correct, except that instead of two bags, one on

each side, we must think of thousands upon thousands of microscopic bags called air sacs. We must recall what we learned in *Good Health*, and think of each one of these sacs as the expanded end of a tiny tube that ends in it. We must remember that the tubes themselves are the small twigs of larger tube branches, and that within the large chamber which the ribs make we have two sets of these branching tubes ending in air sacs. Each set is called a lung. The heart lies between the right and left lungs, and is a trifle more on the left than on the right side.

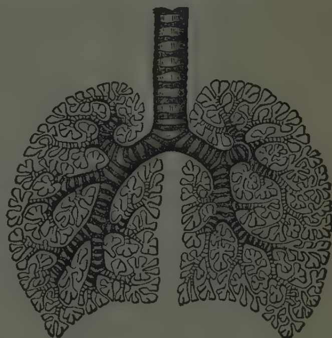
A Hollow Chest

For the sake of saving time and space a few facts, new and old, must be given under numbered headings. They show how the lungs help us throughout our lives:

1. Blood that enters the lungs is so dark and so well laden with carbon dioxide — although there is also some oxygen in it — that we call it impure. Blood that leaves the lungs is so well loaded with oxygen that it has gained a bright scarlet color, and we call it pure, as indeed it is. Even in pure arterial blood, however, there is some carbon dioxide.

2. Lungs are at work not because they themselves need air, but because they serve as a storehouse and

a place where oxygen and carbon dioxide may change places. Such a central exchange is needed because, as we know, here and there over the entire body each smallest tissue is in need of oxygen and must be relieved of its carbon dioxide. It is in the lungs that blood unloads itself of most of its carbon dioxide, loads itself up with oxygen, and streams off to some distant destination. Breathing, then, is mainly for the benefit of the tissues of the body, not for the sake of the lungs themselves.



TUBES AND AIR SACS OF THE LUNGS

3. All the blood of the body comes to the lungs and goes away again once every twenty-three seconds. While it passes through the lungs it does not leave the capillaries, but the capillaries themselves are so closely intertwined with the air sacs that the two cannot be separated. And while they lie thus near together, with capillaries close about the air sacs, rapid exchanges are taking place. Oxygen mixed with the other gases of the air is on one side of the animal membrane of the air sac; carbon dioxide, with a little oxygen, is in the blood on the other side of

the membrane within the capillaries. And as the gases are side by side, two of them — the oxygen and the carbon dioxide — change places without delay. Oxygen enters the blood from the air sac; carbon dioxide enters the air sac from the blood; the red corpuscle carriers are loaded in the twinkling of an eye, and hasten off to unload where their cargo is called for. In the meantime, however, the large supply of carbon dioxide is as unwelcome in the air sac as it is everywhere else in the body. It is therefore expelled as promptly as possible by an outgoing breath.

In view of these three important facts it is quite evident that large, healthy lungs will be invaluable to any one who wishes to take vigorous exercise, and that, on the other hand, this exercise itself is the very best thing that can be done to develop the lungs.

A man is always glad when his chest measure seems to show that he has large lung capacity; and many a man with a narrow chest has tried to enlarge his lungs by raising his ribs, by walking with chest forward, by taking exercises which have given him strong arms, a strong back, and firm muscles across the chest. In so far as these exercises made him breathe deeply he helped himself, but unless he held this fact in mind he may not have gained so much as he hoped, for the surest way to increase the size of the lungs is by exercising the

breathing muscles and by stretching the air sacs themselves. The entire group of sacs should often be compelled to expand more fully than they naturally do in the course of regular daily breathing; and the best way to expand them is not by standing still and taking deep breaths, but by using large muscles vigorously, thus compelling the lungs to work hard too.

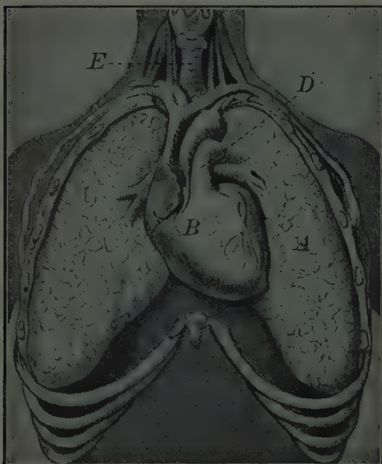
Many a sagging chest hides from sight multitudes of inactive air sacs that have never been expanded through hard exercise. Nevertheless, each separate one would have worked well and would have increased in size if its owner had been intelligent enough to compel it to gain capacity and power through such hard breathing as comes from fast walking, from running or jumping, or from lively games played out of doors.

Groups of Air Sacs

Unless some care is taken, endless numbers of air sacs may stay inactive for weeks together, and end by being a source of danger. Only by the full breath, which is broad as well as deep, does much air get into the upper corners of the lungs, and these air sacs, left inactive, yield quickest to disease microbes when the attack comes. It is indeed just here that tuberculosis most often begins its work. This dread disease makes rapid advance in the lungs of those who have the largest number of unused air sacs.

Even for the sake of future health, then, exercise of the lungs is invaluable. This exercise may be secured in one of two ways:

1. By voluntary full breathing exercises. Ten full breaths taken three times each day will keep the air sacs in active condition. This is much better than nothing.



HEART AND LUNGS IN CLOSE CONNECTION

A, left lung; *B*, heart; *D*, tube through which blood goes to the lungs to be purified; *E*, windpipe through which air goes to the lungs with oxygen for the air sacs

2. By involuntary full breathing. This may be brought about very quickly by giving vigorous exercise to the large muscles of the body. Running and climbing, skipping rope and dancing, anything that uses large muscles fast will fill the air sacs and keep them in good condition. You may prove this for yourself.

While taking exercise or breathing at any other time, keep in mind the following valuable points learned in *Good Health*:

1. Air enters the lungs through tubes that begin with the nose and end in air sacs.

2. As a rule, breathing should be done through the nose and not through the mouth, because the delicate, damp lining of the nose warms the air and cleans it before it reaches the air sacs.[1]

3. It is important to send down well-cleaned air, because the inside lining of each air tube is made of the most delicate membrane and is easily injured. Dust that brings tears to the eyes is even more harmful to the lungs.

With all these facts before him, let the young person who has a narrow or a flat chest set about his own improvement. Let him apply his knowledge and secure for himself a chest that will be a cause for honest pride. If he wishes to be an athlete, he must not forget that the best developed leg muscles are of little use for running unless the lungs and the heart are able to do their share of the work. For, as some one has said, "We run as much with our lungs and our heart as with our legs."

[1] Nothing hinders proper breathing more than adenoids (described in *Good Health*, p. 136). These are growths of tissue in the nose. A child with adenoids suffers in body and mind, as the following case shows. It describes a twelve-year-old boy in Cleveland, Ohio.

"May 1, 1907. Hearing very defective; hears watch at six inches. Sleeps badly, snores, appetite poor, frequent colds, chest development poor, restless, inattentive, apathetic, stupid, eyesight defective, frequent headaches. Adenoids.

"May 3, 1907. Adenoids removed. Eyeglasses secured two weeks later.

"June 10, 1907. Hears watch at four feet, breathes freely through nose, sleeps soundly, never snores, appetite good, marked increase in weight, headaches have ceased. Has been transformed into a calm, calculating, bright, attentive, and well-behaved pupil."

All intelligent people are anxious to have adenoids discovered early and removed promptly. It is a simple operation and quickly over.

CHAPTER XVII

ADULTERATED ALCOHOL AND PATENT MEDICINE

What a man eats and drinks is so important to the welfare of his body that the following facts about drinks which many people use every day cannot be omitted from a practical book on hygiene.

Chemists say that in these days he who uses an alcoholic beverage, whether as a drink or as a tonic, cannot know what he is really taking. He has paid for something which contains alcohol, to be sure, but startling revelations have been made about that which he may have received in its place.

In 1906 Dr. Warren, who was State Food Commissioner for Pennsylvania at the time, made an official statement in which he said:

> Out of 600 samples of alcoholic liquors, 450 samples were found to be adulterated. Wood alcohol causing nerve atrophy, convulsions, impaired vision, blindness, and even death; salicylic acid, causing intestinal derangements, dyspepsia, and kidney diseases; coal-tar dyes that are active poisons and that cause diseases of the digestive tracts; sulphites that have the same effect; red pepper and other powerful irritants, — are some of the adulterations which lurk in many thousands of bottles and kegs of whisky, wine, beer, and other intoxicants that undoubtedly will be placed on sale within the next year. The flood of this

poisonous stuff has just commenced. A new legislature will not meet until January, 1907. It is necessary, in the meantime, that public attention be called to the dangers that lie in the use of adulterated drinks.

On the 15th of April, 1907, the general manager of the St. Louis Wholesale Liquor Association wrote a letter to the liquor trade in which he said:

> We retail dealers have allowed the "reduction rogues" to swindle us out of millions by substituting for good whisky, which we paid them for, a compound that would kill a horse if he drank it. We have unwittingly sold this accursed poison to the youth and the flower of our manhood, many of whom have been crazed, have lost their manhood, their honor, and their all, because they drank it. Their mothers, their sisters, their fathers, their brothers, and their friends are driving us retailers out of business.

Perhaps we wonder why alcoholic drinks should ever be adulterated. Two reasons are given:

1. All the wine-producing districts of America and Europe combined do not supply enough of the different kinds of wines to meet the demands of those who wish to use them.

2. Pure alcohol is heavily taxed, but after the tax has been paid the alcohol can be secretly weakened and cheapened by adding water and drugs to it. Water is added for bulk, and such drugs are put in as will give the desired taste and at the same time make a man feel as alcohol itself makes him feel after he drinks it. Sadly enough for the one who drinks, few things but poison can accomplish this last result.

Those who understand the danger which lurks in alcohol may be inclined to ask if, after all, the water and the drugs do not make a safer mixture for a man than the drink which holds more alcohol. The answer is that such poisons as are used in adulterating alcoholic drinks are often even more violent and more harmful to the body than alcohol itself.

Some time ago the legislature of Ohio asked Dr. Hiram Cox, a distinguished chemist, to make a thorough examination of alcoholic liquors. He worked on the subject for two years, and in a letter afterwards said:

I have made over six hundred inspections of stores and lots of liquors of every variety, and now positively assert that over ninety per cent of all that I have analyzed were adulterated with the most pernicious and poisonous ingredients.

Another letter says:

I called at a grocery one day where liquor was being sold. A couple of men came in while I was there, and called for some whisky. The first one drank, and the moment he drank the tears flowed freely, while at the same time he caught his breath like one suffocating or strangling. The second man drank and went through like contortions. After they had left I asked the proprietor to pour me out a little in my tumbler. I went to my office, got my apparatus, and examined it. I found it seventeen per cent alcoholic spirits when it should have been fifty, and the difference in percentage was made up by sulphuric acid, red pepper, pellitory, brucine, and strychnine.

In commenting about it he says, "One pint of such liquor at one time would kill the strongest man."

Two fishermen bought a pint of whisky. They drank it on the banks of the Ohio River, and that afternoon they were found dead with the empty bottle beside them. When the man from whom they bought the liquor heard about their death, he emptied his cask of whisky into the ditch. There was therefore no proof against him. Nevertheless, all who knew what had happened felt sure that the whisky had killed the men.

No sane man would for a moment think of taking a liquor dealer's recipe book, of which there are many, and putting up for himself a compound of water and poisons such as some of the recipes call for. It would not occur to him that it would be safe for him to drink such a compound. Yet the same man runs a greater risk when he buys a drink at any retail or wholesale place; for the last man who weakened and poisoned the stuff has no more idea than the man who buys it, how many times it has already been weakened and poisoned before it reached his hands. Expensive drinks are quite as unsafe as cheap drinks.

Judging by its name, our port wine comes from Oporto, Portugal. But Mr. Cyrus Redding once made a report on the subject to a committee appointed by the House of Commons, England. He said that every year Oporto exports 20,000 pipes[1] of wine, but that England alone uses 60,000 pipes of this same wine each year. Where,

[1] One pipe is equal to 126 gallons.

then, does the vast quantity of port wine come from that is used in the rest of Europe and in America?

Mr. Redding shows that this is the manufactured result of what has passed from hand to hand through the wholesale and the retail dealers. Water, poisons, coloring matter; more water, more poison, and more color, — mark the steps of its progress until the combination of water and chemicals is finally sold as fine port wine imported from Portugal.

From first to last the work of concealment is so well done that even an expert cannot tell by taste, smell, or color that it is a dangerous compound of chemicals. A chemist, however, with his apparatus can always find the poisons.

These facts, which no one thinks of denying, do not mean that those who use alcohol are in danger of being killed suddenly by it. We ourselves know that this is not true. Multitudes of people drink more or less frequently throughout their lives, and almost never does even a newspaper reporter hear of a man who has dropped dead because he drank.

No, the newspaper reporter is not the one to go to when we wish to know about the life-and-death results of drinking. To get such facts we study the statistical tables of life-insurance societies. There we find that he who uses alcohol reduces his chance for life by weakening the power of his body to resist disease microbes. For

definite facts and figures, turn to the eleventh chapter of *Town and City*.

Aside from alcoholic drinks, however, chemists find that many patent medicines also contain opium, cocaine, alcohol, and other strong poisons. And just because these poisons are so powerful, the innocent victim may find comfort for a season. His nerves may be quieted, his pain relieved. But later comes the curse. That which seemed so helpful often ends by hastening the progress of the disease it was supposed to cure. This is specially true of consumption. Or, instead, the drug habit may be formed through medicine, and a man may discover too late that he is doomed.

Chemists testify that most medicines which go by the name of "tonics," "bitters," and relievers of pain of different kinds contain a large per cent of alcohol. Often as much as one quarter of the entire liquid in the bottle is alcohol.

In view of their disclosures these men and others have insisted that innocent people should not be cheated into the use of any poison through ignorance of what they are buying. These scientists have indeed been so much in earnest and so active in their agitation of the subject that at last the United States government has passed a law which helps the case greatly. It demands that the names of every poison in a bottle of patent medicine shall be printed plainly on a label and pasted on the

bottle. The amount of alcohol must also be stated on the same label.

If a bottle of patent medicine bears no such label, it is evident that its contents hide neither alcohol nor poison; it has no confession to make. If there is a label, remember that, as a rule, each name on it stands for a poison.

He who is unwise enough to buy patent medicine should balance his mistake by being wise enough to study the label before he uses the contents of the bottle.

CHAPTER XVIII

EXPERIMENTS IN EATING

It was a novel thing in the history of the world for men who were connected with a national army to serve their country by being used as a sort of laboratory for

SOLDIERS WHO SERVED ON THE EATING EXPERIMENTS

food experiments. But this was done by certain soldiers of the United States army in the year 1903.

Professor Chittenden of Yale University had decided to conduct some scientific experiments on a rather large scale. He began with himself, enlisted the help of others, and finally had in hand thirteen soldiers whose ages ranged from twenty-two years and six months to forty-three years. Several of these men were Americans. Others were from Porto Rico, from Palestine, from

Switzerland, and from England. They were sent to New Haven from the hospital corps of the United States army, and they submitted to the tests as a part of their everyday military duty.

Close attention was given to the men in several ways. At quarter of seven each morning they were weighed. This was necessary, for they were eating about half as much meat as usual, with somewhat less of other kinds of food, and it was important to know each day whether they were gaining or losing by the new course of diet.

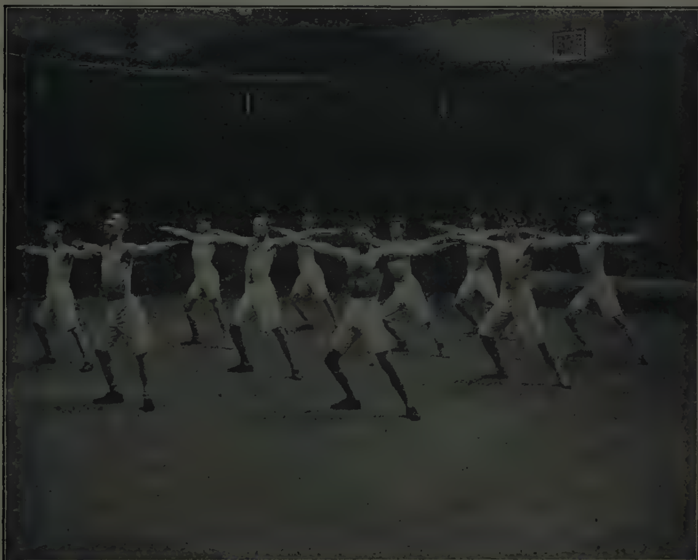
At seven came breakfast. Here each separate kind of food was weighed before it was given to the man who was to eat it. What he did not eat was also weighed, that Dr. Chittenden might know just how much had been used. Moreover, these men were allowed to eat only such food as was served to them. In other words, for each meal they were told when to eat, what to eat, and how much to eat. All eating between meals was strictly forbidden.

Aside from this close care about their food the men were not hampered in many other ways. They went to the theater sometimes, worked in the Yale gymnasium an hour a day, had regular drill under their officers, and went to bed at ten o'clock.

No doubt the whole affair grew monotonous at times, and it has been said that a few of the men were inclined to protest against it. On the whole, however, they went

through it without hesitation, and when they left New Haven at the end of six months, Dr. Anderson, director of the gymnasium, wrote about them as follows:

> The men were not above the average standard physically when they began their work, this standard being set by applicants for positions as



Ten of the Soldiers taking Exercise in the Gymnasium

> firemen and policemen, not by college students. At the end of the training they were much above the same standard, while the strength tests were far greater than the averages made by college men.

These tests did not settle all food questions, but they seemed to make it clear that even soldiers may gain

strength on much less meat than they have been in the habit of eating. As for the rest of us, science has proved that the work of the body is closely related to the food we give it; that the kind of food makes a difference in the quality of the work; that he who works little, harms himself when he eats much, and that growing children need much more food than their inactive elders.

All scientists agree that food does two things for the body:

1. Food builds tissue; that is, it makes the body grow by adding fresh tissue, and it keeps the body new by replacing all tissues as fast as they wear out.

2. Food produces energy by which the body does work and keeps itself warm. Food so used is the fuel for our engines.

We eat, then, for the purpose of meeting one or the other of these two great demands of the body, and our success or failure in life may easily turn on what we know or do not know about the value of our food.

When Professor Chittenden planned meals for his soldiers, his main thought was not as to whether he should give them beefsteak, mutton chops, fish, eggs, bread, or vegetables, but whether or not he was giving them the right proportions of certain substances which living bodies need if they are to do good work. This would be easier to understand if our bodies were blocked off in patches, with each separate substance

firmly held in a special district of its own. In point of fact, however, the few general materials out of which our bodies are built are so closely intermixed with each other in blood and tissue that only the chemist can separate them. The next page shows his work in a table which is made up from the reports of the United States Department of Agriculture. It shows how the materials which the body must have are distributed in some of the foods we eat. In this table the single word "carbohydrate" is used instead of the two words "sugar" and "starch."

Look over the long list, which is only for reference and not to be memorized, and notice that our entire supply of food comes from living and growing things, that is, from plants or from animals. Plants gather nourishment for themselves from earth and air and water. Animals cannot do this. Instead, by their nature they must live either on the flesh of other animals or on material which plants have gathered and stored up for their own use.

This fact gives an added interest to the table of foods. Notice that in every case the animal food is rich in proteid, and be ready to remember that proteid is the food substance which builds the tissues of the body. That is, when muscle is broken down through exercise, proteid is used to build it up again.

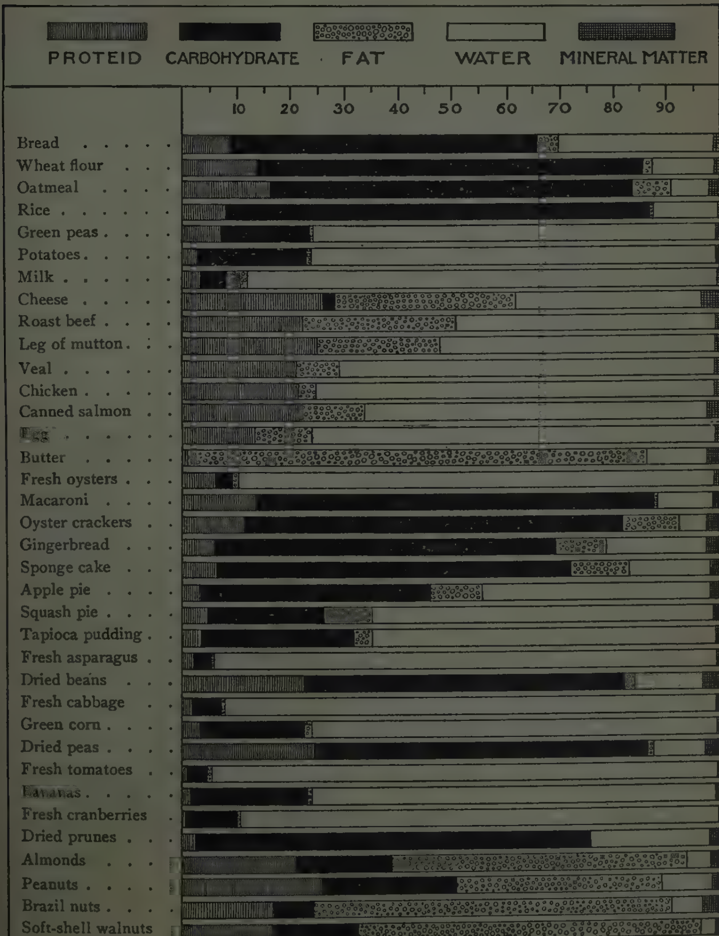
Notice also that the plant foods in this table are rich in carbohydrates, and bear in mind the fact that carbohydrates are the food substances which produce energy

Food Substances as found in Different Articles of Diet[1]

	Proteid	Carbo-hydrate	Fat	Water	Mineral Matter
Bread	8.9	56.7	4.1	29.2	1.1
Wheat flour	13.8	71.9	1.9	11.4	1
Oatmeal	16.1	67.5	7.2	7.3	1.9
Rice	8	79	0.3	12.3	0.4
Green peas	7.	16.9	0.5	74.6	1
Potatoes	2.5	20.9	0.1	75.5	1.0
Milk	3.3	5	4	87	0.7
Cheese	25.9	2.4	33.7	34.2	3.8
Roast beef	22.3	—	28.6	48.2	1.3
Leg of mutton	25	—	22.6	50.9	1.2
Veal	21.2	—	8.0	70.3	1
Chicken	21.5	—	2.5	74.8	1.1
Canned salmon	21.8	—	12.1	63.5	2.6
Egg	13.4	—	10.5	73.7	1.0
Butter	1.0	—	85	11	3
Fresh oysters (solid)	6	3.3	1.3	88.3	1.1
Macaroni	13.4	74.1	0.9	10.3	1.3
Oyster crackers	11.3	70.5	10.5	4.8	2.9
Gingerbread	5.8	63.5	9	18.8	2.9
Sponge cake	6.3	65.9	10.7	15.3	1.8
Apple pie	3.1	42.8	9.8	42.5	1.8
Squash pie	4.4	21.7	8.4	64.2	1.3
Tapioca pudding	3.3	28.2	3.2	64.5	0.8
Fresh asparagus	1.8	3.3	0.2	94	0.7
Dried beans	22.5	59.6	1.8	12.6	3.5
Fresh cabbage	1.6	5.6	0.3	91.5	1
Green corn	3.1	19.7	1.1	75.4	0.7
Dried peas	24.6	62	1	9.5	2.9
Fresh tomatoes	0.9	3.9	0.4	94.3	0.5
Bananas	1.3	22	0.6	75.3	0.8
Fresh cranberries	0.4	9.9	0.6	88.9	0.2
Dried prunes	2.1	73.3	—	22.3	2.3
Almonds	21.0	17.3	54.9	4.8	2.0
Peanuts	25.8	24.4	38.6	9.2	2.0
Brazil nuts	17.0	7.0	66.8	5.3	3.9
Soft-shell walnuts	16.6	16.1	63.4	2.5	1.4

[1] Notice that some of the substances in the table are moist while others are dry; and remember that before many of the dry foods are eaten a great deal of water is added to them. This is notably true of the cereals, of rice, and of flour. For example, what we buy as one pound of rice at the grocer's comes to the table as nearly four pounds of moist food. The chief difference between dry and moist foods is simply that when we eat dry foods we take less of the food and more water. Vegetables, fruit, meat, milk, eggs, puddings, and pies are moist foods. See the quantity of water in them which the table shows.

THE SAME FOOD SUBSTANCES SHOWN IN A DIFFERENT WAY[1]



[1] These tables are made up from facts supplied by Bulletin 28 (revised edition) of the United States Department of Agriculture.

by which the body does its work and keeps itself warm. Proteid also helps in both these directions.

When more carbohydrate is eaten than is called for by the work of the body, the surplus is stored up as fat; and this fat is as important to the body for use in times of extra pressure, as is money in the bank for a man who may at some time need more money than he has in hand. Too much fat is, however, a disadvantage, for an over-supply reduces the power of the muscles.

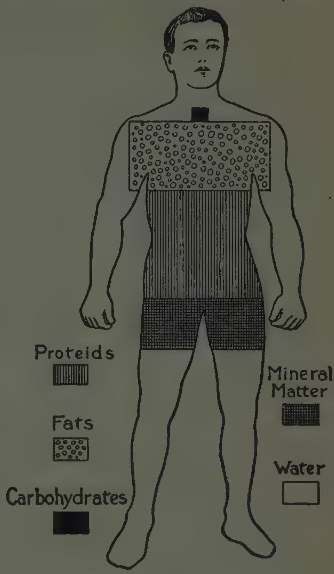
When more proteid is eaten than the body can use, the surplus is sent off through the kidneys. Those who eat too much meat often overtax their kidneys to such an extent that they suffer from rheumatism and gout. More is said about this in Chapter XXII.

Babies grow fast and take little exercise, hence their food — milk — contains both proteid and carbohydrate. Later on the same child will be a man; he will then grow little and exercise much, and will therefore need several times as much carbohydrate (fuel food) as proteid (tissue food).

Study the table of foods carefully and decide which articles may be wisely put together for the same meal. Professor Chittenden himself had these food substances in mind when he planned meals for the soldiers. He knew that all kinds of meat and some kinds of vegetables are rich in proteids; that grains and vegetables are specially rich in sugar and starch (carbohydrates); that

mineral matter which we need comes in table salt and is also found in most meats and vegetables. And he saw, as we do, that the great food questions turn upon the proteids and the carbohydrates. In giving directions, therefore, he was careful to order a mixed diet of carbohydrates and proteids for the same meal. When, for example, he selected beans, cheese, or eggs, he gave little if any meat; instead, he provided foods rich in starch or sugar, with vegetables and fruit, for example, or with some simple sweet dessert.

Housekeepers succeed best when they too keep sight of these proteid and carbohydrate facts. They are then able to make wise and nourishing combinations for their families. They know why a man receives as much nourishment from eggs and beans and cheese, as from steak and



THIS SHOWS WHAT PROPORTION OF THE HUMAN BODY IS COMPOSED OF EACH SUBSTANCE WHICH WE TAKE AS FOOD

Little carbohydrate appears because most of the sugar and starch which we eat is used up in the shape of heat and muscular work and sent from the body as carbon dioxide. When we eat more carbohydrate than we need, the surplus is stored up as fat. The diagram shows that the body keeps a good deal of this on hand ready for use

(Copied from *Practical Hygiene*, by Alice Ravenhill)

roasts. They know why boiled potatoes alone are not as nourishing as creamed potatoes, and why pickles and tea and coffee are almost useless as food.

Just here it should be stated that food is needed not for nourishment alone but for bulk as well. If it were not for this we might be content to have our food condensed into small pellets and swallowed quickly with a mouthful of water. The objection to this simple scheme is that the extended size and length of the stomach and the food tube have to be taken into account. They require food which is bulky enough to be acted upon. Vegetables and fruit have special value for this reason.

Certain vegetables and fruits are also valuable to us for the vitamines which are in them. We shall learn more about this in Chapter XXI.

There are persons who think they must eat meat of some sort every day. So, indeed, they must unless they provide themselves with proteid foods in other ways. Multitudes of people do this. Some drink three or four glasses of milk a day. Others use proteid vegetables such as peas and beans. Still, even if these vegetables are added to the diet, it is well to use milk or eggs when meat is not supplied once a day. Elderly people should eat less and less meat as the years go by.

CHAPTER XIX

CATS UNDER THE X-RAY

It is quite possible that the soldiers and athletes who shared in the eating experiments had no very definite notion about that which was to happen to the food which they swallowed, and it may easily be that some of them had not so much as heard about Dr. Cannon's experiments on cats.

These experiments were carried on in the laboratory of the Harvard Medical School, and the record of the work was published in 1898. Cats were chosen because they are easy to get hold of, ready to eat when they are fed, ready to sleep at almost any time, and easily controlled. Even among cats, however, Dr. Cannon had to choose carefully, for only those who were good-natured were useful to him.

Having made his choice, he took bread, mixed into it a harmless chemical called bismuth, fed it to his cats, and waited for results. The bismuth was put in for just one reason. Its presence in the food made it possible to get a shadow of the shape of the stomach by means of X-rays. From shadows he hoped to discover, very definitely, how the stomach moves during the time that it is digesting

its contents. Dr. Cannon was fortunate in the cats he chose, fortunate in his helpers, and fortunate in what he was able to learn through the X-rays; for he learned facts which had never been proved before.

After being fed the cat was put in place for its shadow picture. The particular cat which I have in mind was fed at fifty-two minutes after ten in the morning. At eleven o'clock work was well under way in the stomach, and once every half hour after that, until twelve minutes after six in the afternoon, the kindly cat consented to be put in place to have its shadow studied. Dr. Cannon traced the shadows one by one, so that an exact record was kept of the size of the stomach from the time of the hearty feeding until there was nothing left to be digested.

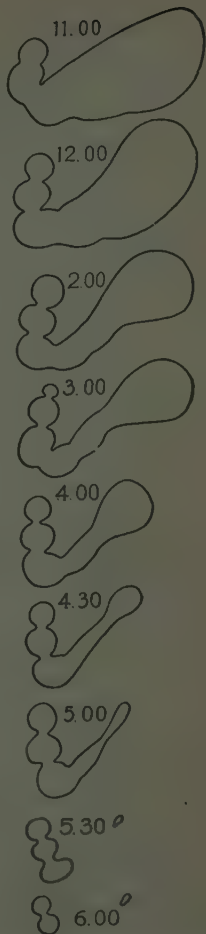
During this time there had been an interesting course of events. When first seen the stomach looked like a small leg of ham with a curled-up tail to it. But when six o'clock came, the leg shape had disappeared entirely, leaving nothing but the tail to show where the food had been. Moreover, at this time, the cat seemed hungry and called for food, with which it was promptly rewarded.

The diminishing size of the stomach was perhaps one of the smallest lessons learned that day; for while the cat slept, and while the X-rays were focused on its stomach, another fact was noted. It appeared that food which had newly arrived stayed quietly in the upper

end of the stomach as if it were in a reservoir. Here the saliva which had been swallowed with the food had a longer time to do its share in the work of digestion. But as fast as supplies were needed further on, this reservoir contracted itself and sent its contents forward a little at a time.

It was also seen that the firm walls of the lower part of the stomach had begun to contract in a series of wave-like movements. These waves started near the middle of the stomach and moved towards the smaller end of the elastic bag. They followed each other in regular succession. Once every ten seconds a new wave took its start from about the same spot and traveled the same course down to the smaller end.

Indeed, whenever the shadows were studied during that day, these waves were seen to be following each other with unceasing regularity. Moreover, as time passed, and as digestion progressed, this middle



CONTRACTION OF CAT'S STOMACH (MUCH REDUCED) DURING DIGESTION

part of the stomach grew gradually more and more slender, like a neck, while the larger end stayed large for a longer time.

Through his study of shadows Dr. Cannon learned that within about fifteen minutes after food is swallowed, a slender jet of softened food goes with a spurt through an opening at the lower end of the stomach and out into the tube which is the beginning of the small intestine.

For all animals, including man, this exit for the contents of the stomach is guarded by a strong muscle called the pylorus, or keeper of the gate. And well does this keeper do its work. Sometimes, with every wave that rolls in its direction, it opens wide enough to allow a spurt of digested liquid food called chyme to go through. But sometimes it stays persistently shut while wave after wave pushes in vain in its direction.

For the sake of getting an explanation of this uneven action of the pylorus, Dr. Cannon induced the cat to swallow a small specially prepared tablet made up of starch paste on the outside and of bismuth the size of a pea at its center. He then watched the progress of this pellet in the stomach. He saw it stay for a long time in the large, bulblike end; saw it gradually make its way farther and farther down as it was sent forward by the waves of contractions; and finally saw that for forty-two minutes after the pellet reached the pylorus that diligent gate keeper allowed nothing to pass onward.

Over and over again the round bit of bismuth and the mass of soft food in which it floated, came up to the pylorus as if to demand free passage through. And over and over again, just as often, the soft as well as the hard was positively rejected and sent shooting backwards, only to come again and again to be rejected.

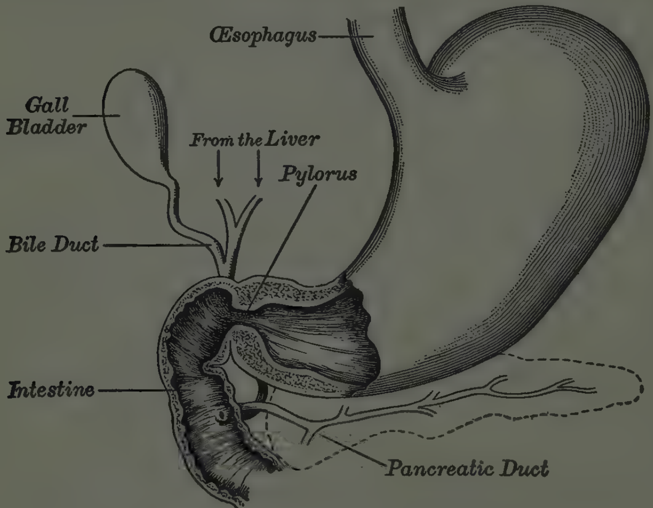
This was kept up until finally the most fluid of the food was refused no longer. It went onward. Later yet the pylorus seemed to give up all protest. It seemed to conclude that there was no hope of ever softening the bismuth. This also was then permitted to go on in company with food which was well prepared for advancement.

From this experiment it is evident that the disadvantage of any hard substance in the stomach is not simply that it is itself slow in passing on through the pylorus, but that it delays the progress of even such food as has already been reduced to chyme — food which should be receiving its next course of treatment in the food tube. The main objection to slow digestion is that after food has stayed too long in the stomach it grows sour and gives off gases which stretch the walls of the stomach and cause distress of various kinds.

The next time you eat in a hurry and are tempted to swallow unchewed lumps of food, think of all this and control yourself in time.

During the X-ray experiments there came an unexpected turn to affairs one day. Thus far Dr. Cannon had

been fortunate enough to have dealings with amiable cats only. They had eaten when he wished, had been quiet and well-mannered during the experiments, and had slept when required. In addition, their stomachs had gone



THE HUMAN STOMACH

Food reaches the stomach from the mouth through the œsophagus. While digestion goes on, bile runs from the liver directly into the intestine; at other times the opening of the bile duct is shut, and instead of entering the intestine, bile passes into the gall bladder, where it is stored until needed. The outline of the pancreas is shown by a dotted line

steadily to work when food was put into them, and had kept ploddingly at it until digestion was accomplished.

But a different type of cat came to Dr. Cannon's hands one morning. This one ate as promptly as the others, and when the X-ray was arranged the shadow showed at

first that the usual regular wave action of the muscular walls was taking place. Suddenly, however, the animal lost his temper. He seemed to feel outraged that anything should be going on which he did not understand. He refused to purr as did the other cats; he insisted on being released. Being in such a state of mind, he was useless and had to go. But before he was dismissed it was seen that all the action of the waves had stopped. So much so, indeed, that the stomach was as inactive as if it were empty of food.

This led to close observation of the connection between the feelings of a cat and the behavior of its stomach during digestion. These observations in turn led to the startling discovery that whenever a cat is unhappy or disturbed in its mind by anger, anxiety, or distress of any description, the muscular action of the stomach comes to an end.

To prove this conclusively, those who carried on the experiments were obliged to tease a well-disposed cat a little, even while it was under the rays. Before the teasing it purred gently, and the wave contractions swept on with rhythmic regularity. But when the teasing began, and when the cat began to feel mental distress and to show it, every wave ceased — the stomach stopped its work abruptly and absolutely. If, then, Dr. Cannon stroked the cat, it was at once happy; it purred, and with that purring began again the squeezing and the

monotonous, regular progress of the waves along the walls of the stomach.

Doctors have always known that an unhappy man does not digest his food so well as the same man when he is happy; but none have known just why this is so. It is evident, however, that there is some close connection between happiness and the power of the stomach to keep up the squeezing movement of its waves.

In view of this discovery, nothing could be clearer than the fact that if we wish good work from our own stomachs, we must be neither worried, nor anxious, nor angry, either during the time that we are eating or so long afterwards as food is in our stomachs waiting to be digested. For the simple sake of health, therefore, the calm and happy mind is greatly to be desired.

CHAPTER XX

FROM FOOD TO BLOOD, OR PERISTALTIC ACTION AND THE VILLI

In the same laboratory of the Harvard Medical School, and probably on the identical cats already described, a second set of experiments was to show what the history of chyme is after it has gone through the pylorus into the tube which receives it.

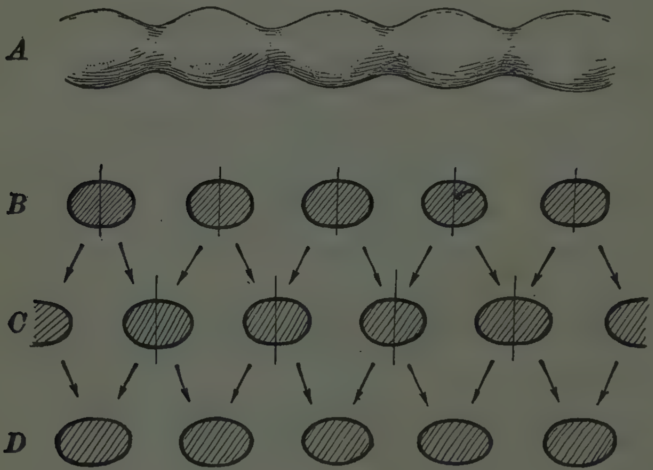
This tube, which in man is about twenty feet long and about three inches around, is folded back and forth in compact compass just below the stomach. It is called the small intestine; and within it go on some of the most marvelous of our involuntary muscular contractions.

The entire scientific world was in doubt as to precisely what happens in the tube until, through the X-ray, through the cats, and through Dr. Cannon's continued experiments, the mystery became a series of surprising facts that could be understood perfectly well.

Previously scientists had known that chyme, as it leaves the stomach, is as liquid as pea soup; that certain juices are promptly poured upon it from the liver, the pancreas, and the lining of the tube; and that, in its most liquid state, the food passes through the sides of

the small intestine and is sent into the blood supply of the body.

All this has been acknowledged for many years. It has also been stated distinctly very often that food



THE FOOD TUBE AND ITS CONTENTS

A, the tube as it contracts at regular intervals; *B*, the contents of the tube after the first contraction; *C*, after the second contraction; *D*, after the third contraction. The line through the middle of the oval piece shows where each was divided by the tube as it tightened just there. The arrows show how the new halves were alternately forced apart, and then driven together again by the repeated contractions of the tube itself

which leaves the stomach as chyme is to be called chyle while it makes its journey through the long tube. It is well to remember these new words and these statements, for they make the continued history of digestion easier to understand.

After the stomach had done its work through waves of motion; after gastric juice had softened and dissolved the food by degrees; after the pylorus had allowed such chyme as was soft enough to pass through its narrow portal; after bile from the liver and pancreatic juice from the pancreas had turned this chyme to chyle, then followed what proved to be a most surprising discovery.

At first the X-rays showed the shadow of the chyle as it lay along in the various loops of the folded tube. All was inactive and quiet for a season. The chyle was motionless and gave no sign of progress. But slight warnings followed, — a quiver at first, a mere agitation. Then, without further delay, activity began in earnest. The stretched-out length of chyle within an entire loop was suddenly divided into separate bits. Each bit was of the same size as all the others. The tube indeed, without apparent cause, had tightened itself at regular intervals. Like a flash it had divided its contents into a series of oval masses of equal size. After this it halted for a moment. But within two seconds there was another contraction, and each bit was now divided through the middle. Their halves were compelled to unite with neighbor halves on either side, and a series of new whole ones appeared.

Thus, back and forth with every two seconds of time, the rapid peristaltic action was continued.

While it lasted the small particles were alternately so quickly divided and so quickly forced together again that

Dr. Cannon speaks of them as rushing together "with the rapidity of flying shuttles, the little particles flitting towards each other and the larger segments shifting to and fro, commonly for more than half an hour without cessation."

In the meantime the food within the tube was advanced but slowly on its way. It seemed to stay in place for no other purpose than to be acted on by the squeezing and the relaxing of the tube. Whether the chyle was thin or thick, whether the activity of the tube was slower or more swift, the squeezing was kept up so unweariedly that each particle of chyle was affected by it. All that lay within the folds and turns of the small intestine was brought into contact with the sides of the tube tens of thousands of times while it was gradually being absorbed. That which could not be used went on into the large intestine, whence it would finally leave the body.

To an ignorant person this endless activity might seem to be a waste of energy and a needless hindrance to the chyle as it works its way along. In point of fact, however, rapid movement of chyle through the food tube would be a distinct disadvantage; for, from the time food is swallowed until its journey is ended, the one necessity is that it should be thoroughly prepared to be used by the regiments of threadlike villi which line the small intestine. Chyle, indeed, is improved by

every juice and every squeeze which it receives before it is absorbed by the villi. So true is this, that food which does not get the treatment it needs will be rejected by each villus which it meets as it travels downward, and will end by forming part of the final waste of the body. When this occurs to food which we have taken the pains to cook and chew and swallow, not only does the body lose the strength it should have had, but the tube itself is in danger of becoming clogged. And here it is that we face again the problem of body waste.

VILLI THAT FORM THE VELVET LINING OF THE FOOD TUBE

A cut through the wall of the tube, showing some dark blood vessels and four villi

With all that we eat, there is, of course, much that can never be turned into chyle and blood. As we know, however, this is useful as bulk. But nothing hinders digestion much more, or breaks down general health much faster, than the results which come from retaining waste in the body after it should be sent off. Even as meat and vegetables decay in the pantry on a warm day, so too is it with waste in the body. Both in the pantry and in the food tube decay

comes from the action of microbes, and from both places decaying food should be cleared away promptly. The habit of getting rid of waste at a definite hour each day, whether in the morning or in the afternoon, is of priceless value; for that which the villi reject is worse than useless to the body.

It would seem, then, that from first to last each mouthful of food which we swallow is being put into shape for the villi, and that they use it or not without the slightest reference to our wishes in the matter. This indeed is true; and the number of these independent workers is counted by the hundred thousand and the million. Each separate one is a tiny finger-shaped structure, ready to absorb such chyle as shall meet its demand; each stands beside its neighbor, helping to make the soft, velvety lining of the twenty feet of tubing; each does its independent work; yet all are united in drawing nourishment from the chyle and in sending it on to the body through the blood.

Just here certain facts should be reviewed and condensed:

1. It is through the lining of the small intestine that all substances must pass — whether proteid or carbohydrate, fat, water, or salt—which are to enter the blood from the food we swallow.

2. The villi are, in point of fact, the lining itself drawn up into slender tubes for the sake of

increasing the surface against which the chyle must be pressed.

3. Food passes through the villi much as lymph and plasma pass back and forth through the sides of the tubes that carry blood. This food must, therefore, be very liquid, for the villi cannot absorb any solid substance.

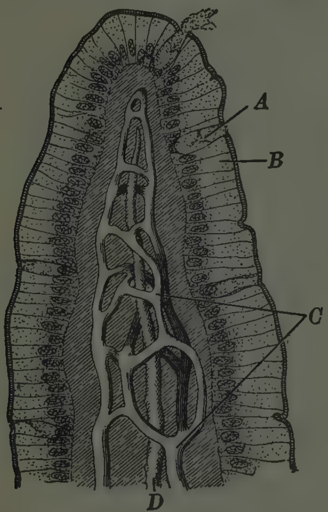
4. The great object of peristaltic action is to wash the chyle up against the villi, that they may be constantly bathed with fresh supplies of it.

5. The mouth with its teeth and its saliva softens food and prepares it for swallowing; the stomach with its gastric juice softens it still further and prepares it for the pylorus; the food tube with its contributions from the liver and the pancreas gives to what we eat its final preparation for the villi.

When chyle which is squeezed against the villi is such as they can use, they absorb it and send it on through other tubes into the current of the blood. When, however, this chyle is not liquid enough, or not changed enough in other ways, they refuse it as absolutely as if it were a poison to them.

For each of us almost any well-cooked food can be turned into chyle which will pass through the villi; yet many a thin man and many a half-nourished woman shows by every sign of face and figure that the villi are not getting what they can accept.

In almost every such case the explanation lies in some mistake which the person is making. Perhaps he eats so fast and chews so little that saliva does not have a chance to do its share of work. Perhaps he is so busy just before and just after eating, that blood is drawn away from the stomach, leaving it less vigorous than it should be. Perhaps he worries so much, is so anxious and troubled about many things, that gastric juice fails to form and is thus kept from doing its part of the work. Or it may be that the unfortunate person has overeaten until his whole digestive system has rebelled. Whatever the cause, we know that we are nourished or starved according as we have been successful or not in preparing chyle for its last examination. If teeth and tongue, saliva, stomach, gastric juice, bile, and pancreatic juice have done their work well, the final test will be successfully met and passed; the villi will accept the food, and we shall be nourished. If the test is not met, we shall suffer from lack of nourishment.



A VILLUS, CUT DOWN THROUGH THE MIDDLE

A, a cell which manufactures mucus; *B*, the outside layer, which absorbs chyle; *C*, capillaries to supply each villus with blood; *D*, lymphatic

CHAPTER XXI

GLAND LABORATORIES FOR THE AID OF APPETITE AND GENERAL HEALTH

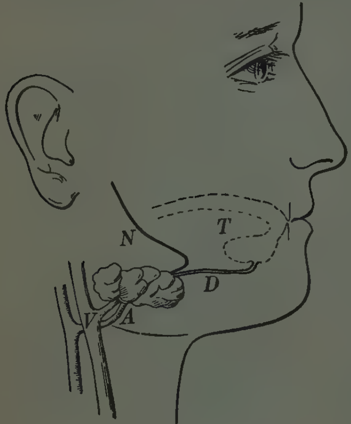
Although they did not understand what they were doing, dogs no less than cats have helped scientists who have tried to explain the laws of digestion for us. One such dog had a small tube fastened so ingeniously to his mouth that the saliva ran into it as fast as it was formed. Professor Pawlow watched and described the tests one after the other:

> I now offer such an animal a piece of flesh, and, as you see, the tube fills up at once with saliva. I stop tempting the dog, hang on a new test tube, and give it a few pieces of flesh to eat; once more a strong secretion of saliva results. A new tube is now attached to the funnel, the dog's mouth is opened, and a pinch of fine sand is thrown in; again there is a flow of saliva. One may employ a number of substances in this way, when a similar effect is always produced.

Many different students have established the fact that the mouths of dogs and of men too are supplied with three sets of salivary glands, and that for dogs and men alike, one or the other of the two following causes are enough to make saliva flow:

1. A great desire for some special kind of food.
2. The chewing of the food.

Prove these statements for yourself. Think of the most delicious thing you know anything about, and notice the effect on your mouth. Then again, when meal time comes, or even now if you can get it, take a dry crust and see what you can do with it by the mere act of chewing. Use your jaws vigorously, and before long you will find that you have turned that dry bread into something as easy to swallow as a mouthful of mush.



A Salivary Gland

A, artery; *V*, vein; *N*, nerve; *T*, tongue; *D*, the tube through which saliva, manufactured by the gland, is emptied into the mouth

A wise man with weak digestion often chooses toast, crackers, and crusts rather than the most delicate custards. He makes this choice because he knows that dry food requires more chewing than food which is soft, and that for this reason it will receive the most from his salivary glands. He recognizes the value of three facts:

1. Saliva has the power to turn starch — a carbohydrate which cannot be used by the villi — into sugar, a carbohydrate which can be absorbed into the body. This is a different kind of sugar from that which we eat in food or in candy. Saliva also helps

change certain sugars which are hard to absorb, into other sugar which is easy to absorb.

2. The more saliva we mix with the carbohydrate which we eat in bread, potatoes, and other foods, the better prepared will that carbohydrate be for its next course of treatment.

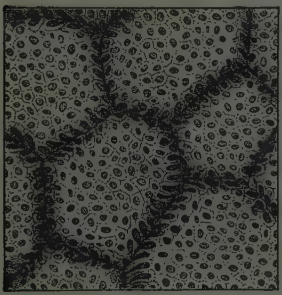
BRANCHES OF A GASTRIC GLAND HIGHLY MAGNIFIED

Gastric juice is here manufactured for the use of the stomach

3. Saliva which we swallow with our food will continue to act upon it during the time that it stays quietly in the large, upper end of the stomach, waiting to go on.

Carbohydrate, however, does not stand alone in its need of help from the mouth. A baby is allowed to draw no more than the finest stream of milk through the mouthpiece of his bottle. Those who feed the child seem to know that when milk reaches the stomach it is curdled at once, and that it is much better to have it curdle in small flakes, that can be more easily digested, than in one large lump which will be slow in digesting. Young babies who are allowed to drink milk rapidly from a tumbler are not likely to gain so much nourishment from this milk as they would if it reached the stomach a little at a

time. The same is so true for older people, too, that wise doctors strongly advise all human beings, whether young or old, to take their milk in sips and not in a pouring stream which will curdle in a mass as soon as it reaches the stomach. Milk is swallowed slowly, therefore, not because it needs the help of saliva, but because it is more quickly digested when it has been curdled in flakes.



A FRAGMENT OF THE LINING OF THE STOMACH MAGNIFIED 20 DIAMETERS

Each spot shows the mouth of a gastric gland through which gastric juice flows into the stomach

After being swallowed, food finds itself in the region of the stomach where there is rhythmic agitation from the waves of contraction. Here gastric juice acts upon it.

This colorless acid fluid can dissolve almost any proteid substance. A dog swallows an unchewed chunk of raw meat and the stomach digests it, not by tearing it to pieces, but, in a real way, by dissolving it through the aid of gastric juice. Even the human stomach easily digests unchewed raw meat, but cooked meat needs more chewing and more help from the saliva. Moreover, gastric juice is needed for both cooked and uncooked meats.

Numberless small gastric glands manufacture this liquid. They are packed snugly side by side within the

lining of the stomach. There each is supplied with its separate tube, ending in its own special outlet; and the juice which these hosts of glands manufacture and empty into the stomach is of immense value in continuing the work of getting food ready for the villi and the blood.

As to what makes gastric juice flow fastest, and how the supply may be more or less controlled, Dr. Pawlow learned many things through his tests with the dogs.

> The stomach has been washed out half an hour ago, and since then not a drop of gastric juice has escaped. We begin to get ready a meal of flesh and sausage before the animal, as if we meant to feed it. We take the pieces of flesh from one place, chop them up, and lay them in another, passing them in front of the dog's nose, and so on. The animal, as you see, manifests the liveliest interest in our proceedings, stretches and distends itself, endeavors to get out of its cage and come to the food, chatters its teeth together, swallows saliva, and so on. Precisely five minutes after we began to tease the animal in this way the first drops of gastric juice appear. The secretion grows stronger and stronger till it flows in a considerable stream. The meaning of this experiment is so clear as to require no explanation: the passionate longing for food, and this alone, has called forth under our eyes a most intense activity of the gastric glands.

In carrying on these experiments Professor Pawlow made it plain that dogs should not simply be tempted, but should be really fed with that which has tempted them.

Several other facts were brought out by the same tests. Each was valuable from a scientific point of view, and I give them in close succession:

1. The more eagerly a dog desires food the more gastric juice will flow.

2. Gastric juice flows fastest and longest in connection with food that is enjoyed the most; for some dogs this is raw meat, for others cooked meat, etc. Dogs have preferences as well as men.

3. The mere fact that something is in the dog's stomach does not make the juice flow.

4. We all understand that the more the juice flows, the better will the food digest.

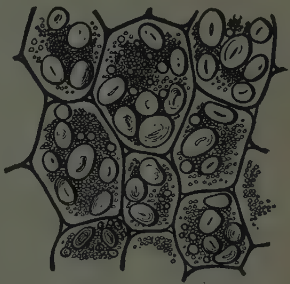
From these important facts, learned from the study of digestion in dogs, men have learned why it is that a good appetite helps digestion. Indeed, those who make an application of the facts to their own lives come to the conclusion that hunger, if it is not too long continued, is one of the greatest blessings of life, and that he who eats only when he has earned an appetite for food is surest to gain the most nourishment from that which he puts into his stomach, because while it is there it will receive the richest supply of gastric juice.

But aside from digestion itself there is the great matter of preparing food for the glands even before we eat it. The fact that we cook our food is an enormous help in two important directions:

1. Cooking kills microbes. Recall the typhoid experiences of the cities on the Merrimack River, as they are described in *Town and City* (Chapter XV),

and remember that boiling would have killed the disease microbes and made the water safe to drink. The same treatment will kill other disease microbes, whether they are in milk or meat or food of any kind.

2. Cooking breaks starch cells open and makes it possible for saliva to get hold of the starch and help turn it to sugar.



FROM THE SEED OF THE BEAN

The larger granules are starch; the smaller ones are proteid

We know already that unless this starch is turned to sugar, every villus in the long tube will reject it, whereas if the change has been made it is quite sure of being accepted.

And now we turn to vitamines. During the war between Japan and Russia in 1905 thousands of soldiers suffered from a disease of the legs called beriberi. These men lived mostly on polished rice; that is, on rice from which the hulls had been polished off. Many other people who lived on the same diet were afflicted with the same disease. And doctors were eager to find a cure. At last someone suggested that beriberi victims should try eating the polishings of rice as well as the rice itself. They did it and the disease disappeared.

Scientists next carried on special food experiments with rats, mice, guinea pigs, pigeons, monkeys, and men.

Through these experiments they learned that a vital element of our food lies in the coating of the rice grain, which is polished off before we buy it and eat it. They also learned that similar elements are found in the bran of wheat, in leaf vegetables like lettuce, spinach, raw cabbage, beet greens, Swiss chard, Brussels sprouts, and celery, in tomatoes (raw and cooked), in citrous fruits such as oranges, grapefruit, lemons, and limejuice, also in uncooked, unskimmed fresh milk, in cream, butter, cod-liver oil, and in the yolks of eggs. It seems that in each one of these foods there are vital elements called vitamines. Nowadays, therefore, food specialists talk of vitamines and urge us to use food that contains them.

Dr. McCollum speaks of "protective foods." He says, "Milk and the leaves of plants are to be regarded as protective foods and should never be omitted from the diet. . . . Milk is our greatest protective food." By protective foods he means foods so rich in vitamines that they help the body to ward off disease when disease microbes threaten. No wonder, then, that the wisest among us now give ourselves a generous supply of vitamines every day of our lives. We follow the food laws given in Chapter XVIII. In addition, we use protective vitamine foods. We are also glad to know that oranges are better for us than candy, because they supply the glands with vitamines for the benefit of the whole body. We next study the largest of these glands.

CHAPTER XXII

GLAND LABORATORIES INFLUENCED BY ALCOHOL

In case you are thin enough to do it, you might slip your fingers up under the edge of the lowest ribs on your right side. There you will feel the smooth outline of the largest gland in your body. It weighs between three and four pounds, and it is to this place that the villi send much of that which they gather from the chyle. Indeed, it is only after this gathered liquid food has gone into the liver, and after a valuable substance called glycogen has been made out of it, that it is ready to be used by the tissues of the body. The liver, then, is a chemical laboratory where food gets its final preparation for the blood.

More than this, a large part of the impure or venous blood, on its way back to the heart from the capillaries, passes through the same great gland. There it is relieved of broken-down tissue and other waste which it has gathered from the body. From part of this waste the liver manufactures bile. Here, then, we have the circle of the occupations of the liver:

1. It changes liquid food which it receives from the villi into glycogen, which the body needs for nourishment.

2. It takes certain wastes from the blood, makes them over, and forwards them in the blood to the kidneys, to be separated there and sent from the body.

3. It manufactures bile as needed. This is sent to the small intestine where it helps digestion and afterwards escapes with the other wastes of the food tube.

Clearly enough, no man who knows these facts and who wishes to make sure of his health will care to ignore the welfare of his liver or to act as if he were ignorant of the laws which control it. Nevertheless, many of the discoveries about these laws are so recent that even well-informed people have sometimes failed to hear about them.

This is true of my neighbor, who complained about his liver the other day. He said the doctor advised him to eat less, to exercise more, and to give up his beer until he was in good shape again. He himself protested, however. He said: "What I really need is strength, you know, and how can I get strong by eating less? As for beer, so far as I can see, it is the one thing that really helps me. Can't I judge by my own feelings?" The doctor said he could n't, and the doctor was right. Follow the argument closely.

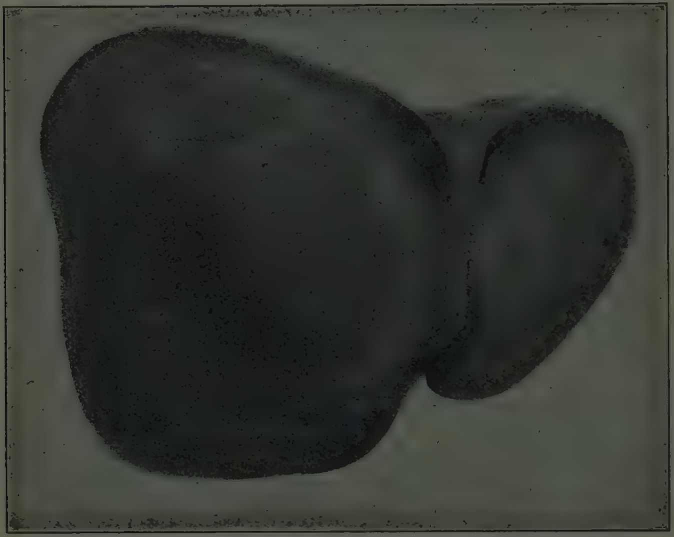
Those of us who have ever seen a piece of raw liver know how extraordinarily bloody it is. We also know that it is bloody not by accident on a particular day, but

that any piece of liver, on any day of the year, is deluged with its own blood. This is inevitable because the liver is always provided with an enormous number of small blood vessels, each one of which is in active service.

When, therefore, the doctor gave my neighbor that advice about beer, he was acting in line with his knowledge of the effect of alcohol on blood vessels in general. He knew, what we also know, that wherever there is an unusual supply of capillaries and blood-carrying tubes of all sizes, there will alcohol do its paralyzing work. He knew that when blood vessels in the liver are somewhat paralyzed and enlarged beyond their usual size, the liver itself is sure to suffer in a serious way.

When a doctor examines liver after liver as he finds them in the hospital and in the dissecting room, he counts the ignorance of the unfortunate men no laughing matter. "A drunkard's liver again," he will say as he opens up the telltale gland. "No wonder the man died. It's a wonder he lived as long as he did with a liver of this sort to purify his blood supply for him." That which the doctor finds is indeed a grievous sight; for a liver in the grip of alcohol is often swollen to double its natural size. It has been changed from a healthy, compact mass of energetic cells and tubes to an inactive mass of distended tubes and of cells heavily loaded with fat. In other cases the substance of the gland shrivels through the effect of alcohol.

After a man's liver reaches the point where it can do no more work for him, the man dies and we pity him. But there are multitudes of other people who drink less and suffer quite as truly. By their ignorance of the

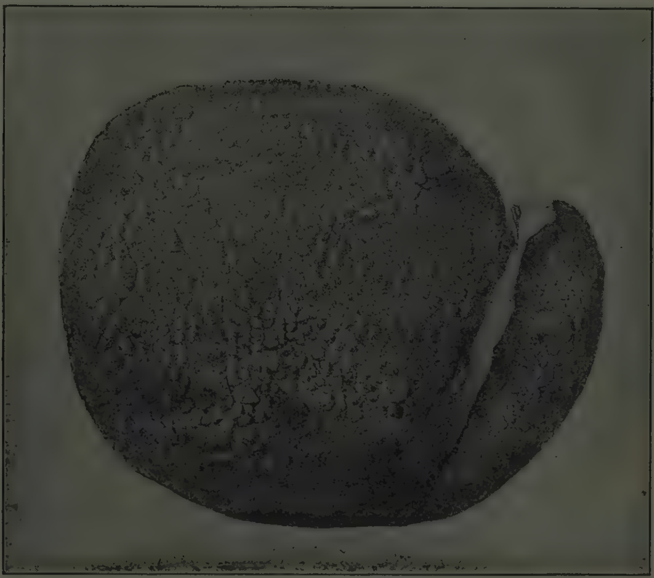


As the Liver looks when doing good Work

(After Horsley)

laws of health, and by their free choice, they are setting a limit to the work which the liver may do for them. In all probability, by their regular use of alcohol they are slowly but steadily securing for themselves a gland which grows gradually more inactive and inefficient,—a gland which, by its inactivity, is quietly preparing them more easily to fall a prey to diseases, or to die

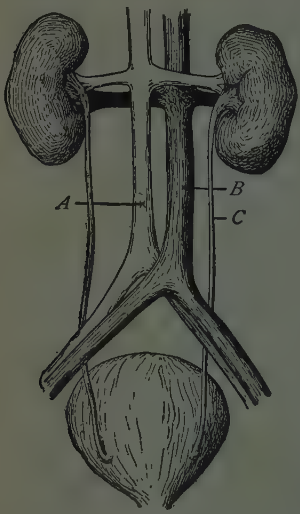
earlier than they might have died. The eleventh chapter of *Town and City* shows what insurance companies have found to be the different chances of life for those who use alcohol as a drink and for those who do not so use it.



A DRUNKARD'S LIVER RUINED BY ALCOHOL
From its appearance it is sometimes called hob-nailed
(After Horsley)

Two other glands are also greatly affected by alcohol. These are the kidneys. They lie on each side of the lower part of the back, and their structure is a marvelous arrangement of closely packed microscopic tubes which are netted about by vast numbers of capillaries.

The special work of the kidneys is to rid the body of many kinds of waste. This brings us round to the subject of food again, and calls our attention to two important facts about the disposal of waste which the blood gathers up:



THE KIDNEYS AND THE BAG WHICH THEY SUPPLY WITH WASTE WATER

A, artery; *B*, vein; *C*, tube through which water leaves the kidney

1. If we have eaten more carbohydrate than we need, the surplus is stored up as fat and glycogen, while the waste takes the shape of water, and of carbon dioxide gas which leaves the body through the lungs.

2. If we eat more meat than we need, the surplus is worked over in the liver and sent off as waste through the kidneys. Moreover, if the kidneys are overtaxed in their work, they fail to clear the blood entirely of its proteid waste; and there is much evidence to show that this waste is definitely related to gout, rheumatism, and kindred ills.

Anything, therefore, that interferes with the prompt, healthy action of the kidneys is a misfortune to us. So true is this that many a man with kidney trouble has

been refused by insurance companies when he wished to get his life insured. Such business houses know that a person who has upset the power of his kidneys is a "poor risk." Because of this, intelligent men listen intently when scientists tell them that alcohol has a direct effect on the kidneys, and that the kidneys are specially affected by weak alcoholic drinks taken in large quantities. It is indeed a fact recognized by all doctors, that those who use beer regularly, even though they drink it moderately, are repeatedly found to have trouble with their kidneys.

A CUT THROUGH THE KIDNEY

Notice the clusters of slender tubes; each separate one might be called a *laboratory*

Not only does alcohol make the capillaries of liver and kidneys inefficient, but it benumbs the working power of each gland. It robs them of their ability to be thoroughgoing, wide-awake chemists. For this reason it is as much of a calamity for these glands to receive alcohol as it would be for human chemists to be made stupid by the same alcohol during the time that they are carrying on important investigations in a modern laboratory.

CHAPTER XXIII

HAMPERED BY CLOTHING, OR ABOVE AND BELOW THE DIAPHRAGM

Men and women who are alive to-day well remember the time when fashion declared that any woman who wished to be well dressed and stylish must have a small waist. Of course we all know that a woman's waist is, naturally, just as large for her size as a man's waist is for his size. But once upon a time fashion said to women, "No matter what the natural size of your waist is, you must manage to make it small somehow."

It was then that the lacing began. And after that, in many lands, thousands upon thousands of women crowded their soft bodies into an unnatural shape. Young women did it, and old women too. One and all they were ignorant. They knew nothing about the harm they could do by their lacing.

This went on for many years. In fact the fashion for small waists has come and gone from early times until now. The fashion itself changes, but the harm done is ever the same. This is why we must study the subject and learn why tight clothes are objectionable.

By knowing, we shall be able to save ourselves whenever the fashion comes round. Study the picture.

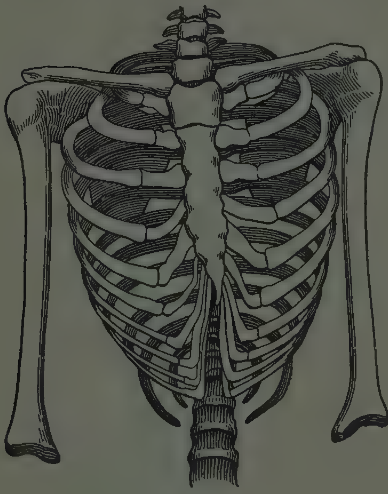
We know that this woman has something hard and firm about the middle, soft part of her body, and that she has drawn this bandage up with such vigor that, at this moment, folds of crumpled flesh lie in creases just underneath the whalebones and the steel. We know that she is most uncomfortable from the pressure, but that she endures it with a smiling face because she thinks she has made herself more slender and beautiful to look upon. Her ignorance goes even further. It makes her willing to do more than simply rob herself of comfort.

SHE LIKES HER LOOKS; WE PITY HER IGNORANCE

Follow her condition down through those folded rolls of flesh and skin. Imagine that some new kind of X-ray is ready to reveal a few miserable secrets, and count them up for yourself:

1. You will find yourself studying a liver which is crowded into such small compass that its capillaries and tiny tubes are folded and pressed upon

each other until they labor under enormous disadvantage. This liver can neither do good work in preparing glycogen from the liquid food which it has received, nor thoroughly purify venous blood of its waste, nor manufacture other things from this waste. No wonder, then, that the waste, kept in the system, is gradually giving to this particular woman a dull complexion. Few things more quickly rob a face of its bright pink and white than an inactive liver. By studying faces and waists you will have no trouble in coming to the conclusion that those who lace are apt to be the ones who paint and powder the most. Evidently they try to conceal the fact that the liver is not doing full work and that the complexion needs repairs.



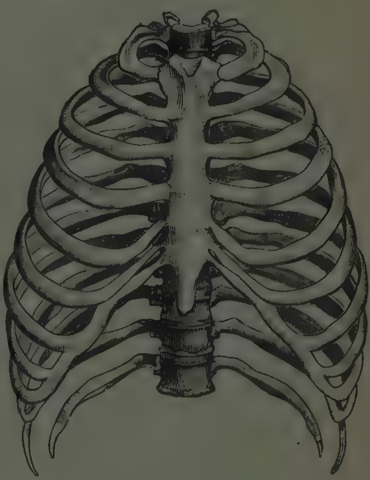
Ribs of a Young Woman who died at the Age of Twenty-three

(After Tracy)

2. Under the bandage the stomach endures the same pressure as the liver. It has less space in

which to carry on its operations. It is consequently so hampered and hindered that indigestion often follows, and nothing is more fatal to a beautiful complexion than the results of this condition.

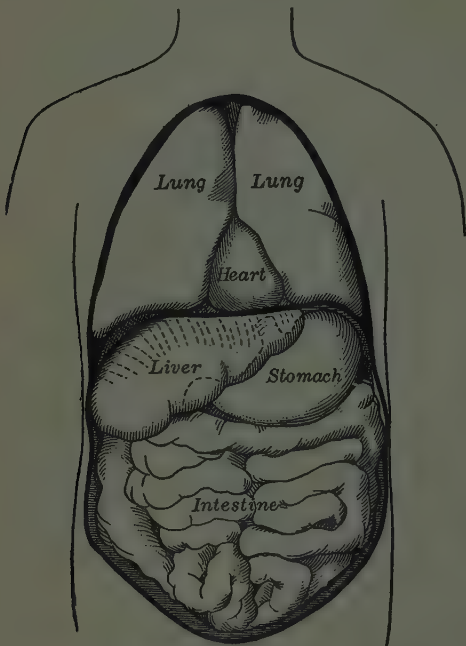
3. The upper long folds of the small intestine are pressed downwards. They too become inactive; food moves slowly through them. The disadvantage in this event is that the longer the food tarries on its way, the more probability is there that it will decay and produce gas. Such gas is immensely uncomfortable because it stretches the walls of stomach and tube alike, and we feel the stretching.



THE SHAPE THEY SHOULD HAVE HAD

Lacing does not always explain the size of the abdomen, for fat often settles there as persons grow older. But when a woman has persistently crowded her intestines downwards, they finally stay out of place without the crowding. The walls of her abdomen are relaxed and flabby because they have not been able to get exercise. Everything which they inclose and which they

should hold snugly and firmly in place is left sagging downwards. Each organ must therefore carry on its business as best it can under most unfavorable conditions.



INSIDE ORGANS THAT WERE SQUEEZED WHEN SHE LACED

This we find to be the state of affairs below the diaphragm. But what about the fate of the diaphragm itself? Give attention for a moment to what it is and to the work it does for us.

In a way it may be hard to think of ourselves as a double-story set of apartments, but such we are. For, stretching across us from side to side, a little above the waist line, is a strong, broad, elastic partition of muscle called the diaphragm. Below it lie liver, stomach, intestines, and other important organs. Above it are the heart and lungs with the large and small tubes which belong to them. Through the diaphragm go several good-sized tubes, a large artery, a large

vein, and the tube which carries food from the mouth to the stomach.

Above the diaphragm, then, we find the organs of respiration and circulation, while below it lie the organs of digestion and the great gland, — the liver. Above the diaphragm blood is ridding itself of carbon dioxide; below the diaphragm blood is getting supplies of nourishment to carry to the tissues of the entire body.

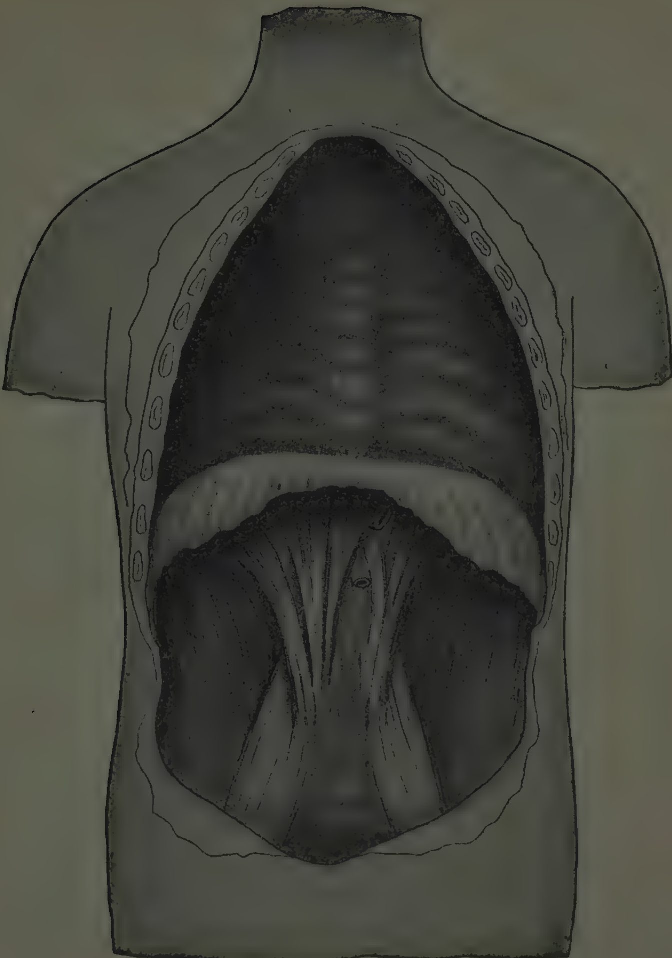
But what active share does the diaphragm take in all this? Find out for yourself. Draw a deep breath. You may perhaps think that you are simply expanding your chest to the utmost. The truth, however, is that the drawing of your breath means that you are not only raising your ribs, but that you are also contracting your diaphragm from every side. A healthy person in hygienic clothing can prove it in this way: lay your hand on your chest, and take pains that the chest shall make absolutely no movement. You will find that you can breathe quite well by letting the abdomen expand and contract, without the least motion of the ribs. By doing so you have flattened down the dome shape which it usually has. When you can contract it no further, you know that your lungs cannot be forced to hold more air. This we call forced breathing. Through it you have forced your lungs to their full size.

But natural, daily breathing is no less dependent on the diaphragm. This muscle is indeed the largest and

the strongest breathing muscle we have. When it contracts, air rushes into the lungs, and the upper story of the body grows larger, while all that lies in the lower story is exercised by the pressure of the diaphragm down upon it. When again the diaphragm relaxes, the pressure is lifted, air is squeezed out of the lungs, and the upper cavity is smaller again.

Liver and stomach also receive decided help from this rhythmic exercise, which continues throughout the days and the years of our lives. And the ignorant lady who laces, implies that she is ignorant by her willingness to interfere with the healthful, regular action of her tireless diaphragm. By putting pressure on her lowest ribs and also on the organs contained both in her chest and in her abdomen, she limits the work which her diaphragm can do not only for her lungs but also for her liver and stomach and small intestine. Moreover, she keeps these organs under such constant outside pressure that they have no chance for the relaxation which is also of importance to them.

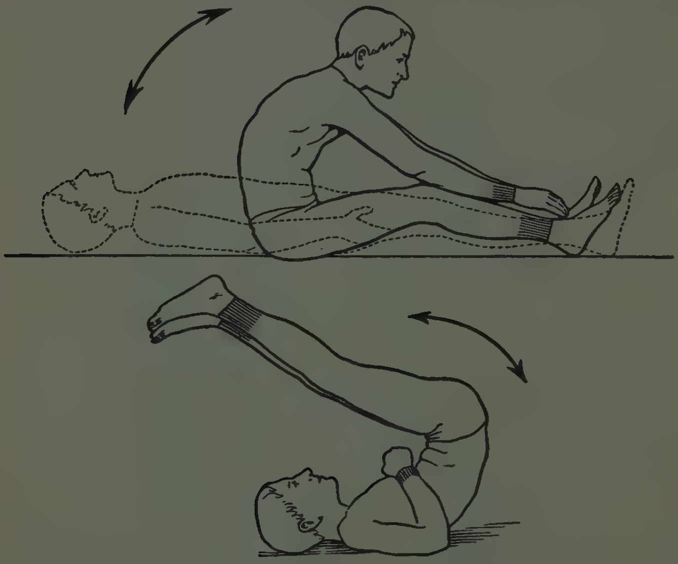
Place your hands on opposite sides of your body; crowd in your ribs and come to your own conclusions as to what you have done to your lungs and to your heart. You cannot conceal the fact that you have crowded multitudes of lung cells out of service, thus robbing the blood of oxygen, and that your heart is pressed against by the surrounding lungs.



THE DIAPHRAGM WHEN IT IS RELAXED

The organs from above it and below it have been removed

When the most important servants of the body are left to the power of the foolish hands of a woman who is ignorant about her own structure, and when these hands give cruel treatment to servants which do her hardest work for her, is it strange that rebellion follows?



EXERCISES WHICH MAY BE TAKEN TO STRENGTHEN THE MUSCLES OF THE ABDOMINAL WALL

(After Schmidt)

Is it surprising that "liver trouble," and gas, and headache, and the blues, and unhappiness, and nervousness fill the woman with lamentation?

In the face of the fashion plates and the laced-up ladies, it is a curious fact that hardly ever does a

woman or a girl acknowledge that her clothes are too snug for comfort or for health. She generally assures us that they are really loose.

We ourselves, may of course, be exceptions; but we must remember that even slight pressure long continued is harmful.

Test yourself. Stand with your back to the wall, with head, heels, and elbows touching it. Draw a long, deep breath. Can you do this without feeling that bands, strings, buttons, or hooks are being pulled at rather vigorously? If, at the same time, you have no weight of clothes dragging down on your abdomen, you may count yourself as well tested. You have passed the examination and may congratulate yourself that you are not preparing your body for defeat later in life.

If, however, you feel the pressure of something that binds you, you need to make a change somewhere. Bands and belts should always be large enough to allow us to do our ordinary breathing without feeling that we are hampered by our clothing. When we take unusual exercise we breathe deeper, expanding our lungs more, and our garments should be proportionately loose.

It is unwise both for growing girls and for grown women to hold their skirts in place by strings drawn tight about the waist. A yoke to the skirt is better, or skirts may be carried by straps or by waists that hang from the shoulders. In other words, weight should not

be allowed to drag down on the abdomen. Learn to protect the strength and the shape of your abdominal wall by putting it under such conditions as will leave it firm and useful when you are grown. Remember that the better you can breathe, and the more freely gland laboratories are allowed to do their work, the better able will you be to endure the strain of life and to resist disease of every sort.

Even now, multitudes of well-informed women dress according to their knowledge of these facts; and the same knowledge is spreading so fast among the young, that, from the signs of the times, it looks as if small, deformed waists would soon be as unfashionable as are the small, deformed feet of a Chinese lady.

CHAPTER XXIV

FOOD OR DRINK FOR OKUSHIRI ISLANDERS

Okushiri is an island in the beautiful sea of Japan. It is about fourteen miles long, and lies not far from the coast of the large island of Nippon.

When the events now to be recorded took place, the population of Okushiri numbered about two hundred and fifty. A mere handful of poor fishermen they seemed to be, but from their obscurity and their poverty they raised themselves into fame and prosperity.

In 1884 these people were distributed in four villages. They lived in houses made of grass, supported themselves by fishing, had but four roads and but one school. Worst of all, a famine threatened, for the price of food was high, and their own catch of herring had been so small that year that they had little money with which to buy other kinds of food.

One thing, however, they had to comfort them in their poverty. They speak of it themselves: "The people have no other pleasure for body and mind than in the use of sake.[1] Nine out of ten of us like the liquid, and what we annually spend for the same is not small."

[1] The national alcoholic drink.

To us who read about it, the amount of sake which they used seems very large, for we are told that during the single year of 1884 the inhabitants of Okushiri imported eight hundred and eighty casks of sake for their own use, and had besides a goodly stock of brandy and other drinks. They intended to be well provided with this one thing which consoled them in their misery and helped them to forget their hunger.

Happily, however, there are as wise men in Japan as in other lands. And, most happily for the fishermen, one of these wise men was governor of the district of Japan to which Okushiri belongs. When, therefore, this governor made his regular visit to the island in 1884 and saw the poverty of the people, saw that famine threatened them for the winter, and also saw how well prepared they were to comfort themselves with their sake, their brandy, and their other drinks, he gave the subject close attention.

Furthermore, he made an estimate of the size of their drink bill for the year, and his figures proved that they were spending money, out of all proportion to what they earned, on sake which did not nourish them, when they were in sad need of the same money for food which did nourish them.

Being a clear-headed man, he had no doubt as to what should be done, and he urged the people to turn the tables immediately. He begged them to provide for

the future by saving what they were really wasting in the present.

Evidently these fisher folk had logical minds, for they gave heed to his counsel. They acknowledged that their debtors could not pay them what they owed, that some of their own number would have to depend on the government for food, and that the condition required an immediate, desperate remedy. Those who were most deeply impressed by the situation drew up a formal statement in which they said:

> We are in misery, and to save ourselves from the wretched state of things, we must have recourse to some extraordinary means. Frugality is to be resorted to, and vanity of all sorts must be set aside. We, therefore, before all others, will abstain from the use of what we relish more than all other things — *sake* — and thus close the way of importation of the liquid into this island. The money we should spend for it will be spent for rice and other grains, and thus we will provide for our future wants on the one hand, and will increase our capital in fishery on the other.

In carrying out this determination, those who originated the plan drew up a formal document in order that they "might secure," as they said, "the prosperity of the island." They called upon all those "who like to share in our privation for the good of the public and the future" to "come speedily and sign the contract." This was in July, 1884.

The document which the islanders were asked to sign held ten different statements, which were put in

the form of a contract. Those who signed this contract pledged themselves neither to buy nor to sell alcoholic liquor of any sort for five years, and to give no aid to such inhabitants of Okushiri as persisted in the buying or the selling of it. For any breaking of the contract there was a heavy fine, and all such fines were to be spent in buying rice, which should then be hoarded in a common granary. Those who bought alcohol were to be fined half as much as those who sold it. All immigrants from other provinces were to be taught promptly about the prohibition plans of the island, and no one was to be admitted who did not understand the situation thoroughly. Such persons as bought alcoholic liquor in any form from passing ships or boats were to be taxed to the full extent of the law.

Last of all, the following statement was distinctly made:

> This contract is to be in force for five years; and when the provision for years of scarcity is fully made and each and everybody is able to lead an independent life, proper changes shall be made upon further deliberation.

One hundred and seventeen Okushiri islanders signed the contract. It was rigidly enforced for five years, and at the end of this time still other records show what the results were.

It was now 1890. Not a drunkard was left on the island. Some had been reformed by giving up the

drinking habit. Others who were too weak to change had gone elsewhere to live. Those who stayed had prospered greatly, while their numbers had increased five-fold. The money which they had put into the fishing industry had multiplied itself by ten. They had even started a new line of work, for now they raised their own hemp and made their own fish nets. Their houses were larger and better made, their schools had improved in quality and in numbers, additional roads had been constructed, and there was less crime. From being spoken of with pity by neighboring islands, as was previously the case, these fishermen were now referred to as "the prosperous people of Okushiri."

The five years had certainly brought good results. Okushiri islanders were no longer a poor and miserable people. Famine did not threaten them now. Was it necessary, then, to keep sake and brandy out of the island any longer? This was the great question of the day for Okushiri in 1890. They discussed it thoroughly and answered it by deciding that for still another stretch of five years they would travel by the road which had led them to such happy results. According to last reports they were still going without alcohol and were still prospering.

In other lands those who are interested in the question of profit and loss have asked themselves whether or not it is a good investment to put money into daily

drinks of beer. They have looked into the matter quite as thoroughly as did the governor of Okushiri, and have come upon a striking set of facts. By making careful inquiry about prevailing prices in America in 1908, they found that if a person should drink three glasses of beer a day during one year, he would spend, on this drink alone, enough to buy the following articles. They are placed one under the other, that they may be read easily.

1 barrel of flour
50 pounds of sugar
20 pounds of cornstarch
10 pounds of macaroni
10 quarts of beans
4 twelve-pound hams
1 bushel sweet potatoes
3 bushels Irish potatoes
10 pounds of coffee
10 pounds of raisins
10 pounds of rice
20 pounds of crackers
100 bars of soap
3 twelve-pound turkeys
5 quarts of cranberries
10 bunches of celery
10 pounds of prunes
4 dozen oranges
10 pounds of mixed nuts
3 tons of coal at five dollars a ton

CHAPTER XXV

WHY NATIONS RID THEMSELVES OF ALCOHOL

France and the Liquor Problem. On the eighteenth of December, 1902, in the city of Paris, France, a report was made by a committee of the government. The state officials considered this report so valuable that they ordered copies of it to be printed as posters in large black letters on a white background.

These posters were placarded here and there on the important buildings of the city. They were put on the walls and in the corridors of hospitals, on the streets, in the post offices, and even on the outside wall of the great Hôtel de Ville, where the business of the city is carried on.

A few extracts will show what it was that the government wished to proclaim in this public way.

DRAFTED BY

Professor Debove, Dean of the Faculty of Medicine
Dr. Faisans, Physician to the Hôtel Dieu

Alcoholism is chronic poisoning, resulting from the habitual use of alcohol, even when this is not taken in amounts sufficient to produce drunkenness. Alcohol is useful to nobody, it is harmful to all. It leads,

at the very least, to the hospital, for alcoholism causes a great variety of diseases, many of them most deadly. It is one of the most frequent causes of consumption. Typhoid fever, pneumonia, or erysipelas, which would be mild in a sober individual, will rapidly kill the alcoholic. Alcoholism is one of the most frightful scourges, whether it be regarded from the point of view of the health of the individual, of the existence of the family, or of the future of the country.

After the beginning of the Great War in 1914 France went even farther and absolutely prohibited the manufacture and sale of the intoxicant absinth.

Russia and Prohibition. In Russia, in 1914, when the war began, orders were issued that thenceforth there should be absolute prohibition of alcoholic drinks. This meant that in a country where 150,000,000 people had been using all the liquor they cared to pay for, no more should be either manufactured, bought, or sold. In describing what was done, Professor Helenius Sepälä, of the University of Helsingfors, Finland, says:

On the sixteenth of October, 1914, all the old stock of ale in the beer shops was, by order of the authorities, poured out on the ground. . . . Everywhere in Russia, including Siberia, the Caucasian provinces, Courland, etc., the sale of distilled liquors and strong wines is strictly prohibited. . . . I walked about the capital one day after another, stepping into restaurants both in main streets and in side lanes, and feeling like a dreamer because the sights I had formerly seen everywhere in the Russian capital I now no longer saw. . . . I did not see drunken men and women, I did not find whisky or vodka anywhere. There were great festivals going on, the streets were filled with people overpowered by their patriotic emotions, it being the birthday of the czarevitch, but all the time I did not see a single person the worse for liquor.

The English Method. In England during the World War the consumption of liquor was reduced by greatly increasing the taxes on it and by giving the government full power to control the saloons in places where war material was being produced and transport work done.

The Japanese Liquor Law. In Japan the law of the land forbids the sale of alcoholic drinks to those who are under twenty years of age.

The Movement in America. In the United States the war gave new impetus to the prohibition movement. On the sixteenth of March, 1918, the government ordered a five-mile-wide dry zone around every army and navy training camp, and at four o'clock that afternoon every saloon in Annapolis and forty-nine saloons in Newport, Rhode Island, had to close their doors. This is a sample of what happened all over the country. In some places the government itself drove the saloons out of business for the sake of the soldiers and sailors; in other places cities and states did the same thing for the sake of those who were not soldiers or sailors but who needed the same protection.

The greatest victory came on the seventeenth of December, 1917, when the House of Representatives in Washington met to discuss the question of national prohibition in the United States. The discussion began at eleven o'clock in the morning and continued until five o'clock in the afternoon. Then came the roll call

and the announcement by the Speaker of the House that 282 votes stood recorded for prohibition and 128 against it. On the following day the Senate decided the same way by a vote of 47 to 8.

Here are the exact words of the referendum bill of national constitutional prohibition, which had aroused the deepest interest all over the country:

> Section 1. After one year from the ratification of this article the manufacture, sale or transportation of intoxicating liquors within, the importation thereof into, or the exportation thereof from the United States and all territory subject to the jurisdiction thereof for beverage purposes is hereby prohibited.
>
> Section 2. The Congress and the several states shall have concurrent power to enforce this article by appropriate legislation.
>
> Section 3. This article shall be inoperative unless it shall have been ratified as an amendment to the Constitution by the legislatures of the several states, as provided in the Constitution, within seven years from the date of the submission hereof to the states by the Congress.

It is easy to see that this federal amendment put a new responsibility upon every state in the Union. Even though a state had been dry for many a year, the legislature of that state had to vote for this particular amendment within the next seven years if it wished to help get national prohibition.

It is important to know that three fourths of the states must ratify — which means vote for — any federal amendment before it can become part of the constitution of the United States.

Notice also that Section 1 says that national prohibition was not to be enforced until one year after the states had ratified the amendment.

As you read the following list, notice that Nebraska was the thirty-sixth state to ratify. This meant that just one year later — that is, on the sixteenth of January, 1920 — there would be national prohibition for the United States of America.

Now read the list and see how fast one state after another stepped into line and voted for the federal amendment. Do not try to memorize the different dates.

Mississippi, January 8, 1918; Virginia, January 10, 1918; Kentucky, January 14, 1918; South Carolina, January 23, 1918; North Dakota, January 25, 1918; Maryland, February 13, 1918; Montana, February 19, 1918; Texas, March 4, 1918; Delaware, March 18, 1918; South Dakota, March 20, 1918; Massachusetts, April 2, 1918; Arizona, May 24, 1918; Georgia, June 26, 1918; Louisiana, August 8, 1918; Florida, November 27, 1918; Michigan, January 2, 1919; Ohio, January 7, 1919; Oklahoma, January 7, 1919; Maine, January 8, 1919; Idaho, January 8, 1919; West Virginia, January 9, 1919; Washington, January 13, 1919; Tennessee, January 13, 1919; California, January 13, 1919; Indiana, January 14, 1919; Arkansas, January 14, 1919; Illinois, January 14, 1919; North Carolina, January 14, 1919; Kansas, January 14, 1919; Alabama, January 14, 1919; Iowa, January 15, 1919; Colorado, January 15, 1919; Oregon, January 15, 1919; New Hampshire, January 15, 1919; Utah, January 15, 1919; Nebraska, January 16, 1919; Missouri, January 16, 1919; Wyoming, January 16, 1919; Wisconsin, January 17, 1919; Minnesota, January 17, 1919; New Mexico, January 20, 1919; Nevada, January 21, 1919; Vermont, January 29, 1919; New York, January 29, 1919; Pennsylvania, February 25, 1919.

Surely that list would be one of the most surprising things in the world if it were not for the following second list. This one might be called the *Honor Roll of States and Territories that had already voted for State Prohibition even before they voted for the Federal Amendment and National Prohibition.*

Maine, 1851; Kansas, 1880; North Dakota, 1889; Oklahoma, 1907; Georgia, 1908; North Carolina, 1909; Mississippi, 1909; Tennessee, 1909; West Virginia, 1914; Alabama, 1915; Arizona, 1915; Virginia, 1916; Colorado, 1916; Oregon, 1916; Washington, 1916; Arkansas, 1916; Iowa, 1916; Idaho, 1916; South Carolina, 1916; Nebraska, 1917; South Dakota, 1917; District of Columbia, 1917; Alaska, 1918; Indiana, 1918; Michigan, 1918; New Hampshire, 1918; Montana, 1918; New Mexico, 1918; Texas, 1918; Florida, 1919; Utah, 1919; Ohio, 1919; Nevada, 1919; Wyoming, 1920.

Porto Rico, 1918; Island of Guam, 1918; Territory of Hawaii, 1918; Virgin Islands, 1919.

In each case the date given shows just when the prohibition law had begun or was to begin to operate in that particular state. Do not try to remember the dates, but take note of the fact that the great battle against alcohol in the United States won its first big victory in Maine in 1851, and that the fight kept on until the federal-amendment victory in 1919.

The following are prohibition triumphs that came shortly before the federal amendment was ratified: a law that forbids sending liquor advertisements into states in which liquor advertising is unlawful; a law

that forbids the shipment of alcoholic liquors to individuals in prohibition states; a law that forbids the manufacture of distilled spirits — that is, whisky, brandy, and gin — for drink; a law that forbids the sale of intoxicating liquor to any soldier in uniform. Each of these was a victory in itself, and each helped on the great final victory.

Canada. Here too prohibition has forged ahead. Province after province crowded alcohol out of its markets and off its tables until, by the last of 1918, the whole of Canada became practically a liquorless land.

In early days there were two great arguments against alcohol: (1) the harm it does to the body; (2) the mischief it does to society. To-day, however, a giant new argument has been added — the hunger of the people who need food. Barley, rice, corn, grape sugar and sirup, — all splendid food materials, — with millions of pounds of other edible things, are turned into beer every year. The realization of this is, indeed, part of the power that drove the prohibition movement to victory.

Taxes, Crime, and Poverty. No doubt thousands of citizens in every land have in mind the taxes which they must pay to help support the poorhouse, the courthouse and jail, the reformatory, the insane asylum, the orphans' home, and the police force of every state and city. In these days we all know that the larger part of the occupants of these institutions are where they

are because they themselves or their ancestors used alcohol as a beverage. Mr. Henry M. Boies, who studied the subject for years in America, said that drunkenness alone cost the United States $420,000,000 a year. Statistics for London, England, show that this one city pays $5,000,000 a year for the expense of its drunken paupers, and in every place it is the honest man, through his taxes, who helps pay these enormous bills.

Fortunately the entire world is awakening to the serious harm which alcohol does to society in every way, and this explains the dawning era of prohibition.

CHAPTER XXVI

PROTECTED BY THE SKIN

There is no doubt about the value of the work which certain scientists did in 1775. These men were anxious to know how much heat the body of man can endure and still keep at its work. For the sake of making no great blunder, they began their tests by passing from one heated room to another until they found themselves living and breathing in a room in which the thermometer showed a heat of 210° F.[1] This is but two degrees cooler than the temperature which water needs for boiling.

As may be imagined, the air of the room felt very hot. One man, however, stayed in it for ten minutes. During this time the heat was so great that it twisted and broke the ivory frames of all the thermometers but one. More than this, the air which the man inhaled was so much hotter than that which he exhaled, that, with each breath which he drew, he felt as if he were scorching his nostrils. But with each exhalation his nostrils were cooled again. He took the thermometer in his hand and blew on it. At once the mercury sank in the

[1] Fahrenheit.

tube, showing that his breath was cooler than the room. He blew on his fingers and they were cooled too.

In another experiment afterwards, the same men went into a small room which was even hotter than any they had been in before. Here the thermometer showed 260° F. This, then, was forty-eight degrees hotter than water needs for boiling. As they entered, the air felt hot but they could bear it. And while they stayed there they did various things to show what the heat of the room was able to accomplish. They took a piece of raw beefsteak, left it uncovered, took a pair of bellows, blew the heated air across the steak for thirteen minutes, and found that it was rather overcooked. An egg was roasted hard in twenty minutes; water soon boiled and bubbled; watch chains became too hot to be touched; and rings had to be left off, lest the heated metal should burn a deep circle about the tender flesh of the finger. Leather shoes could not be worn, for the leather itself curled up and was ruined.

All this happened to their possessions, but the men themselves, although surrounded by the same heated air, were neither boiled nor roasted. They lived and breathed in the place, escaped alive, and their escape was no miracle. It was explained by the power of the sweat glands. If these small laboratories had stayed inactive, the scientists might have suffered from the heat even as did the steak. But their glands were able to save them.

As soon as the men entered the heated room the sweat glands began their work; perspiration was manufactured in quantities; it poured from the open flues of countless small laboratories and emptied itself upon the skin, whence it was evaporated. Thus perspiration kept the skin moist, and the evaporation of the moisture kept the surface of the body cool enough to save it from being cooked. Certainly the men were uncomfortable from first to last, but they did not suffer.

A Sweat Gland and its Outlet on the Skin

The record of these experiments is given in the Philosophical Transactions of the Royal Society of London for the year 1775.

If you ever have the chance, watch the streaming, steaming backs of such men as pitch coal into the huge furnace of an ocean liner. There you will see the same work of protection carried on by these tireless glands. Their exact number is unknown, but by counting a few, in a small area of the skin, and by multiplying this number by the extent of the surface of the body, men estimate that each of us is supplied with about two million sweat-gland laboratories. All are slightly busy most of the time, but only extraordinarily busy when emergencies overtake the body.

Just here review your knowledge of the skin and of perspiration as learned in *Good Health:*

1. The outside layer of the skin is called epidermis. It can be cut or pricked without giving pain. It protects all that lies underneath it, in the second layer of the skin.

2. The second layer — the dermis — holds capillaries, nerve fibers, hair cells with their muscles and oil glands, sweat glands, and pigment cells. These last contain coloring matter — pigment — which gives one boy freckles and another boy tan; which makes one man brown and another man yellow. Both nails and hair are constantly being formed in the dermis and pushed upward.[1]

3. Perspiration is a mixture of water and waste. It is poured out by the sweat glands when the body is heated or exercised. The water soon evaporates and cools the skin. The waste stays on the skin and must be washed or rubbed off; otherwise it mixes with oil from the oil glands, with bits of epidermis, with dust from the clothes and from the air, and stays like a snug, thin, perfectly fitting coat on the outside of the body from head to heel. A thick wrap of this sort interferes with the healthy action of the skin, and gives off an unpleasant smell. It may be removed by a hard, dry rub, and it is

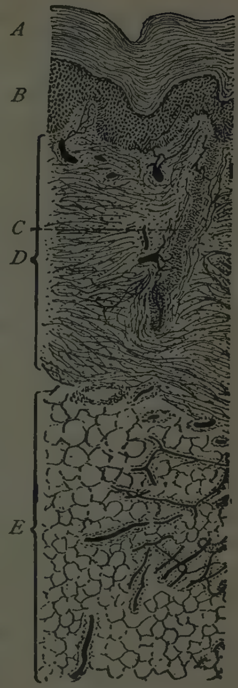
[1] Full directions about the care of both are given in *Good Health*.

important to take the rub whenever a bath is out of the question.

Since the skin is so well provided with blood vessels, it is natural that small wounds should heal quickly. Even when a patch of skin is entirely destroyed by being scalded or burned, there is such power of life left along the edges, that new skin grows out from it day by day until the gap is entirely filled.

But there is a limit to what can be done in this direction, and at such times doctors step in with their wonderful help from grafted skin.

For each of us, however, there is something far more important than hot ovens, burned flesh, and the grafting of the skin. It is not probable that we ourselves shall meet these terrible experiences. But a very practical, everyday danger is always at hand. We may take cold through our ignorance of the laws of skin health and vigor. Let us therefore remember that the skin is constantly covered with a slight moisture called insensible perspiration, and that when there is



CUT THROUGH THE LAYERS OF THE SKIN

A, horny layer of epidermis; *B*, deeper layer of epidermis; *C*, duct of sweat gland; *D*, dermis; *E*, connective tissue, in which the black lines represent blood vessels

enough of this moisture to be noticed it is called sensible perspiration. The purpose of perspiration is to cool the body whenever it is in danger of getting overheated. For the sake of grasping the situation more clearly bear the following facts in mind:

1. When a man is heated from exercise, capillaries in the exercised part of the body are stretched out with the blood which is forced into them.

2. If a heated man, covered with perspiration, sits in a draft, his blood is cooled, the capillaries of the skin contract, and the mass of the blood goes to some other place.

3. When this occurs, the linings of nose, throat, lungs, and intestines are apt to be overcrowded by the blood which has been forced into them from the skin, and the most sensitive lining suffers most.

Usually the first symptom of a cold is that a man feels stuffy in nose, throat, or lungs. The explanation of the feeling is the distended capillaries, with another fact added. Although red corpuscles continue to deal with oxygen as they have always done, still the white corpuscles are now behaving strangely. They get together, many of them stick to the inside walls all along the length of the capillaries, and the more inactive they are, the less do they seize and destroy intruding microbes. These microbes, therefore, remain in the blood and continue such mischief as their nature makes possible.

When a man has a cold the trouble often is that influenza microbes have escaped the white corpuscles and have firmly established themselves in the part of the body which is congested with blood.

In view of these facts it is not hard to understand why a man who has a cold is so much more liable to take other diseases to which he is exposed. He is in a weakened condition, and already microbes instead of white corpuscles have the upper hand.

But suppose a cold is coming on, what does our knowledge of the laws of the skin direct us to do about it?

Draw blood away from the region of the cold as promptly as possible. Do it in several ways: take vigorous exercise until every sweat gland is active; take a hot bath; soak the feet in hot water; drink hot lemonade; go to bed; sleep warm; perspire freely. By keeping warm in bed the blood goes to the surface of the body, and delicate internal membranes are relieved of superfluous blood. White corpuscles are also stirred up, and restoration begins. Stay in bed until the feeling of cold is over. One night may suffice. When you leave the bed be specially careful to avoid every chance draft, for a draft just now will undo the good results of the heat treatment. Take a warm bath at once, then a quick wash with cool water. This will stimulate the nerves of your skin without chilling the blood itself, and keep you from taking cold afterwards.

If going to bed is out of the question, dress more warmly than usual, keep out of drafts, observe every law of general health, and determine to be strictly careful not to expose yourself to colds in the future.

Sitting in drafts or with damp feet, or with clothes damp from perspiration or from rain, is dangerous because in these ways the body may be chilled. A quick, cold, two-minute bath with a hard rub afterwards acts as a tonic and not as a chill to the body.

CHAPTER XXVII

WORK, HEAT, AND FUEL

Let a man live in central Africa or let him travel to the coldest land; let him stay in the burning heat of his city home or wander in the cool shadows of the country; let him be in bed or in the harvest field, in the countinghouse or in the mine; wherever he is, he will find that if he is well the thermometer under his tongue always indicates about ninety-eight degrees of temperature.

In each place also, even if he is not well, the heat of his body will change but little. We say that a man has a slight fever if his temperature is 100° F. If it reaches 102° we grow somewhat troubled; if it rises to 103° and then to 104°, we are truly anxious; for no man is expected to live after his temperature has reached a higher point than 107°.

It is well for us that the body has this power to keep the blood warm independent of outside conditions; for if it were otherwise, — if we were as cold-blooded as is the frog, we should be as useless in cold weather and in cold places as he is. We should have to hibernate in winter as he does.

Birds, as well as all animals that begin life by taking milk from their parents—mammals they are called—are warm-blooded. Each has for itself this wonderful power of meeting the changes of the weather with a constant temperature of its own. As a result, such animals are generally warmer than the surrounding air, and are called warm-blooded for this reason.

Cold-blooded creatures usually feel cold to the hand when we, who are warm-blooded, touch them. Their bodies have no power to stay warm when the air is cold about them.

Although this power is part of our possession, it is nevertheless true that even the heat of our warm bodies can fail. Men do freeze to death. They cannot endure a freeze and then come out of it again, as does the cold-blooded frog. People may live in the coldest countries and be active and healthy there, but the one condition is that they help the body do its work by preventing the escape of more heat than the same body can promptly replace.

Never confuse these two facts:

1. The inside heat of the body changes little from year's end to year's end. If it changes many degrees up or down, we die.

2. The skin feels warm or cold as the air about it changes. Skin and nose and toes may freeze, but the inside temperature remains practically unchanged.

Put a dozen people in a small room, and the room grows warmer because those human beings give off enough heat to warm the air about them. In a cold country or in a cold room each body must keep within itself as much of its own heat as it can. Naturally, therefore, we wear more clothes at one time than at another. We are treasuring up our own supply of heat for our own use.

In the same matter of heat we may ask why exercise helps. Why do boys say, "It's so cold we've got to run to keep warm?" For the mere reason that when muscles contract and when blood moves fast, the heat of the body is decidedly increased. Any one who can get hold of a doctor's thermometer may test this for himself. Put it far back under your tongue and keep it there two minutes; decide what your present temperature is, then take vigorous exercise of one sort or another for twenty minutes and use the thermometer again. If you did not breathe through your mouth, you may find that you have been able to raise your temperature slightly.

Consider also that while you exercised and breathed hard you expelled quantities of warmed air from your lungs. Without doubt, then, taken altogether, your body produced a large amount of heat while it also worked. Now try to explain the source of its power to do these two things. Watch yourself at the dinner table after exercising. You have such an appetite as comes only when

you have been using up your supplies. Food is to the body what fuel is to a stove, and in a certain way your machine has been burning up its fuel while you worked and grew warm. Your appetite is nature's call for a fresh supply of food.

Sometimes active exercise leads the body to call for so much fuel that the stored-up supply, fat, is rapidly reduced. Talk this over with any thoughtful football player and he will tell you that during the football season he loses much of the fat which was stored up by the body during the previous summer. The body has need of extra fuel when it does unusual work, and it then draws on its reserved supply.

A fat man applies this power of the body to his own case. He studies himself both in the mirror and on the scales, and concludes that his body has stored up too much fuel in the shape of fat. He knows that to get rid of it he must compel his muscles to use it, and at once he begins a course of vigorous exercise which gives hard work to large muscles. They respond by calling for fuel, and if he is faithful day after day, the mirror and the scales will soon show that he is accomplishing his purpose, — that he is losing his fat.

Perhaps we wonder how it happens that although we sometimes exercise so hard as to use up much of our fuel, the thermometer shows a gain of so little bodily heat. As we learned in the last chapter, the reason

rests with the sweat glands. They are such a successful cooling device that whenever we exercise enough to raise our temperature above its normal point, they promptly manufacture their clear-colored liquid and send so much of it out upon the skin that the internal temperature of the body is kept from rising too high for safety.

The body is thus seen to produce its own heat, while it also cools itself when we overheat it. Through this power, however, we may take cold unless we know how to prevent heat from escaping too fast when the body needs it. Three rules will be useful in putting this into practice:

1. Never sit long in a room that feels chilly. A long, slow chilling of the body does even more harm than a draft.

2. Never come in heated from hard exercise and cool off in a chilly room. Either continue exercise in the room, or wrap up thoroughly. Best of all, when this is possible, take a quick cool bath and change your damp underwear before you sit down for quiet work.

3. Remember that there is little danger of harm to health, however damp the clothing may be, so long as vigorous exercise is kept up.

Whether our garments are damp or dry, however, it is always true that we are warmed not by the cold we keep

out but by the heat we keep in.[1] Flannel succeeds better than cotton in preventing the escape of heat, because more air is entangled in the mesh of woolen than in that of cotton goods, and air is a poor conductor of heat. For this reason we choose woolen goods for winter wear and cotton materials for our summer clothing.

During a long drive in the face of a sharp wind many a sensible man has slipped a newspaper under his coat. He has acted on his knowledge of the fact that paper is a poor conductor of heat, and that each separate layer of newspaper helps to keep heat from escaping from the air underneath it. In summer, on the other hand, we choose the thinnest clothing and the fewest possible layers of it. We wish to make it easy for the heat to escape.

That which we may do in guiding or in preventing the loss of bodily heat leads us to our knowledge of another fact: *We may so train the body that it will improve in the power to adjust itself to different states of heat and cold.* In other words, the body can be educated.

[1] If the body is not sufficiently covered, heat radiates from it and escapes. Cool air takes its place at once and surrounds the body as a layer. Capillaries in the skin now contract and force the blood away from the surface to the inward parts of the body. These parts then become congested, while the skin feels cold, because the contracted blood vessels can only hold a small supply of blood. By putting on extra clothing at such times and by rubbing ourselves hard, we cause the blood vessels of the skin to expand, more blood passes through them, and we are warm again.

This may be done by following the rules already given and by attending to a few other points:

1. Do not spend much time in overheated rooms, that is, in places heated above 70° F. The body grows exceedingly sensitive to cold if it is kept constantly too warm.

2. Do not overweight yourself with clothing in a warm house, nor take vigorous exercise in heavy garments. In other words, regulate your clothes to your need.

3. If you are in good health, take a quick cold bath every morning. Nothing is better for preparing the blood vessels for changes in temperature.[1]

4. Keep the body clean by a soap-and-water bath at least once a week.

He who attends to the various rules connected with bathing, eating, exercise, and the heating of the body will find, at last, that he has reached the happy condition where sudden changes in temperature and unexpected drafts do not harm him as they did in former days.

The great work of hygiene is to help the body as it tries to help itself.

[1] *Good Health* gives directions about taking this cold bath. Remember that if you feel cold instead of warm after the bath you are not quite robust enough to take it. Some people are so vigorous that they take their cold bath every morning immediately after getting out of bed. Even for them, however, there should be five minutes of energetic exercise beforehand. The time for the quick, cold bath is when the body is warm after exercising. Every good gymnasium is provided with shower baths to meet this need.

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QUESTIONS

Chapter I

How do some cities get the records of a man? Which gives the best record, a photograph or the measurements of certain bones? After what age are bones set for life? Why does a nurse support the head and back of a young baby? How do certain Indians secure flat heads for their children? Describe the case of the baby who always slept with his face turned the same way on his pillow. If his mother had done nothing about it, what would have been the result? Give two laws of bone growth. Describe the appearance of the boy who failed to get work. Describe the boy who secured work. In what ways does the body tell facts about us? How much responsibility have we for the bodies we live in?

Chapter II

Were you satisfied or dissatisfied with the examination of your own body? What points did you decide to change? Mention some objectionable positions to take when seated. Tell why each is objectionable. What difference is there between sitting with a twist in the back once in a while and taking the same position most of the time? What must be guarded against? Was it the older or the younger girls in the German school that had most trouble from lateral curvature of the spine? Why was this? Mention other countries where school children have the same curves. Where, when, and how do children get these curves? Why are gymnastic exercises put between recitations? Mention various positions that bring curves to the spine. What objection is there to these curves?

If the medical inspector finds that you have wrong curves, what will you do about it? Give four laws of prevention.

Chapter III

Mention the case of the strong, bent back and tell how it was secured. Why do certain bicycle riders have bent backs? What law explains the strong but bent back? How did a traveling man lower his shoulder? Describe the backs of two oarsmen, and tell why one is curved and the other straight even when they walk. Why does the hand of a piano player stay open even when he is not playing? Why do the fingers of an oarsman curl up even when he is not rowing? Mention such occupations as you think may change the shape of the body. Why is the body thus changed? Give the second great law about muscles stretching and contracting. How may a man who works in a bent position save himself from the evil effects of his work? Give such examples as you can call to mind.

Chapter IV

What did the doctor tell his audience they could do with their bodies? How did the student show what the muscles can do? How did his back and arms look before he forced the muscles into action? What was it that raised bunches here and there a moment later? How could muscles be pulled up so short and hard without the use of apparatus? What did the man pull against? Was the work done best with or without close attention? What did the lecturer say about the way to develop muscles without apparatus? How often and for how long a time should the exercises be taken? How much change did the student say he had made in the size of his own arm within one month? What should be done to make a close examination of the structure of a muscle? What is a muscle fiber? What can you say about the size and the shape of different muscles? How is each formed? What is the sarcolemma?

Where is the connective tissue? What lies within the connective tissue? Of what use are the fine threads of connective tissues that stretch away from the ends of muscle fibers? What do they help form? How do you explain the difference between tough and tender meat? Why is a spring chicken tender? How can you toughen your own muscle? Describe voluntary muscles. What is the work of involuntary muscles? How much do the muscles as a whole weigh? Can you mention the name of any muscle?

Chapter V

In what way do bones help muscles? How do muscles and tendons help bones? Describe the outside of a fresh bone. Describe the inside of a fresh bone. What is the advantage in having bones made in this way? What would a magnifying glass show? What two things can a chemist do to a bone? What good thing does a cook get from a bone? What are the two important substances which together form bone? Why should aged people be careful not to fall? Why do their bones break more easily than those of children? Why are young bones pliable? If, being young, you wish to change the shape of your chest, how will you do it? Which has the most bones, a man or a baby? Describe the shape of different bones. How many are there in a human being? What is a vertebra? How many vertebræ are there? How are they held together? Explain how vertebræ may become wedge-shaped. What effect does hard work have on the bones?

Chapter VI

Describe the small foot of a Chinese lady. How was it secured? How useful was it? How many bones are there in the foot? How are they joined to each other? In order to have the foot in thoroughly good condition and as useful as possible, how much freedom should the muscles, bones, and tendons have? Which is most desirable, the flat or

the arched foot? How can you decide which kind you have? If you have a tendency to flat feet, how can you help yourself? Why should feet be uncramped? What explains the ruined shape of many feet? In buying shoes, what points should be kept in mind? Why are tight garters objectionable?

Chapter VII

What happened to Alice, the elephant? Why is it often worse to sprain an ankle than to break a bone? What fastens a muscle to a bone? Just how does a muscle help move a bone? Where is the contracting done, in muscle or tendon? What sometimes occurs to the bone when a tendon is badly strained? What connection is there between joints and the direction which bones shall take? Describe the joints which lie between the skull and the spine. Where do we find important ball-and-socket joints? What sort of joint is there at the knee? What is the difference between tendon and ligament? What is it that holds bones to each other? Name two kinds of joints. Where do you find examples of each?

Chapter VIII

In what ways do boys in some cities get their exercise? Of what advantage is this exercise? How does it happen that more attention is paid to the health of children to-day than ever before in the history of the world? What is the object of the Public Schools Athletic League in New York City? Tell what you can about the way it is carried on. How does the victory of a single boy mean victory for his school? What do the best athletic trainers of the country say about the use of alcohol and tobacco by their men? What part of the body does tobacco harm the most? What is the usual record, on the athletic field and in the class room, of those who habitually use cigarettes? Why has the American army often refused men who wished to join it as soldiers? Why

should men with weak hearts keep out of the army? What did Mr. McBride say about the use of tobacco and alcohol by football players at Yale? What does Mr. Edwards say for the Princeton team? What does Mr. Stagg say? What does Mr. Gianini do for the New York Athletic Club? Why did Nansen take no alcohol with him when he left the Fram?

Chapter IX

Tell how you may get the standard of your heart beat when standing. How can you increase your heart beat? By what tests can you prove that your pulse shows what the rate of your heart beat is? What difference do you find in your own case between your normal pulse and your pulse after a short, quick run? What other facts have you learned about your pulse? Is it by the exercise of large or small muscles that you increase your heart beat the fastest? Why does a doctor feel the pulse of his patient? What mistake did a certain frail woman make about the use of her heart? What is the opposite mistake which a bicycle rider sometimes makes? What is the heart and where does it lie? How large is the heart and when does it work? How did the heart of the tennis player show that it was overtaxed? How should the man have begun his playing in the spring? Mention some way by which muscles and heart and breathing apparatus may all be trained at the same time. Describe the work of the doctor as he trained the man who fainted easily. What objection is there to an overstretched heart muscle? Think of some advantages that come from having a heart well-trained for its work. What difference is there in the size of the heart of wild and caged animals? How may you train your own heart?

Chapter X

To what two men do we owe the largest debt for our knowledge about the heart and the circulation of the blood? When did Galen live?

Mention some facts about circulation that were known before Galen made his discoveries. What mistake did those ancients make about the contents of the arteries? What made them think the arteries carried vital spirits instead of blood? Where did Galen practice medicine? What was his first great discovery? What connection did he think there was between the heart and the blood? Who was William Harvey? Where was he lecturing in 1616? What did he notice about the flow of blood from different wounds? What was Harvey's first great discovery? Give some facts that led him to this discovery. How many quarts of blood are there in the body? How much blood does the heart send out each time it contracts? How often does it contract each minute? Where are the pockets in the veins? Which are deeper in the body, arteries or veins? Describe the experiment with the bandage above the elbow. What does it prove? What was Harvey's second discovery? What can you say about the two halves of the heart? What connection does each side have with pure and impure blood?

Chapter XI

Describe the experiment which shows how long it takes blood to make the circuit of the body. How long does this take for a man? for a child of fourteen? Describe the circuit of the blood from the veins back to the veins. How does the blood get from the arteries to the veins for its return journey to the heart? What does the microscope show in the tail of a tadpole? When you cut yourself and blood flows, what have you actually done? What does capillary mean? What can you say about the amount of blood which the blood vessels might hold? In what way is warm salt water sometimes useful in the blood vessels? What connection is there between exercise and the amount of blood which is sent to different parts of the body? Give this law of exercise.

Chapter XII

What is the object in using a rough towel after the morning bath? Describe the way to get a drop of blood for examination. Why do you put the needle in the flame before using it? In getting the blood what have you done to the capillaries? What is the color of the blood? How do you know that blood hardens soon after it leaves the body? What happens to the bit of jelly after it has been left undisturbed for about half an hour? What can you say about the value of blood while a wound heals? What does a drop of blood show when it is examined through a microscope? What three things are mixed together to form blood? Tell all you can about red corpuscles. Describe white corpuscles. What is the liquid part of blood called? Describe it. What does a chemist have to say about blood?

Chapter XIII

What can you say about the importance of getting the blood into close contact with muscle and gland? Describe an experiment with tumblers which proves that certain substances can pass through a moist animal membrane. What have men discovered about the power of certain gases to pass through animal membrane? How will you apply these experiments to the work done by the liquids and the gases within the body? What is lymph like, and where is it found? Which gas passes from the tissues of the body into the lymph? How does this gas reach the red corpuscles? How does oxygen from the red corpuscles get to the tissues? Which two gases change places in the red corpuscles? Tell what you can about blood in the arteries. Describe blood in the veins. Describe lymph. Describe the origin of lymphatic tubes. What is the difference between the system of blood vessels and the system of lymphatic tubes? What does lymph look like? What does plasma receive from lymph? What does lymph receive from plasma? Of what

use are pocket valves in the lining of the lymph tubes? How does vigorous exercise help the body through the lymph? Why is it an advantage to the tissues to be surrounded by fresh lymph?

Chapter XIV

When the nose or any other part of the body is red, what do we understand about the capillaries just there? What objection is there to having blood move slowly through the capillaries? Mention two advantages that are connected with fast-moving blood. Why should the walls of the blood vessels be kept healthy, vigorous, and elastic? What did doctors formerly think about the connection between alcohol and circulation? After a man takes alcohol, does his heart beat faster or slower? What is the sphygmograph for? What does the sphygmograph show about the power of the heart before and after alcohol has been used? It beats faster, to be sure, but what about the force which it puts into each stroke? Does this prove that the heart receives strength or is robbed of strength by the alcohol? What is the natural condition of the blood tubes? Are they elastic or nonelastic? What effect does alcohol have on them? Why is it harmful to have slightly paralyzed blood tubes? What effect has alcohol on the heart? Describe what the result is when both blood tubes and heart are thus weakened. What finally happens to the walls of the tubes? What effect does this have on the exchanges between plasma and lymph? Why does the body suffer when the exchanges are made slowly? Describe the condition of the heart after it has been weakened by alcohol. What objection is there to fat within the fibers of the heart? Why do surgeons dread to operate on a man who uses alcohol?

Chapter XV

If you were ever thoroughly out of breath, describe the sensations you had. When you stopped running, which was most tired, your heart, your

lungs, or your legs? While you ran, what was happening to the substance of the living tissues of the body? What gas was produced by the tissues as they worked? What gas did they need in order to carry on their work? Through what stream did the tissues get rid of their carbon dioxide and receive their oxygen? Why did the blood stream need to flow fast? Give five steps that are connected with breathlessness. What did people formerly think was the cause of breathlessness? What do people think about it now? What can be done to strengthen the heart? When does carbon dioxide form fastest? When do we use the most oxygen? When does a man give off the least carbon dioxide and call for the least oxygen? Why is the heart overtaxed when we run hard? What does a trained athlete learn about keeping the balance of the gases in his blood? When is he willing to be breathless? During exercise, which muscles call for the most oxygen in the least time? Which two organs of the body need to be trained in their relation to each other?

Chapter XVI

Mention some tests which show that the size of the lungs can be increased. How many lungs have we? Where are they? What is an air sac? When is blood called impure? When is blood pure? What is the condition of the blood when it enters the lungs? when it leaves the lungs? In what way are the lungs a storehouse? What exchange goes on in the air sacs? Where is the oxygen taken by the red corpuscles? Is it for the benefit of the lungs or of the tissues that we breathe? How long does it take blood to make the circuit of the body? Describe the way oxygen and carbon dioxide change places in the lungs. Why are large lungs an advantage to the body? How may their size be increased? What are the best kinds of exercise for the lungs? What danger comes from inactive air sacs? Where does tuberculosis most often begin? Why should breathing be done through the nose and not through the mouth? Why should air be well cleaned before it enters the air sacs?

Chapter XVII

Give the chemist's reason for objecting to alcoholic drinks. Who was Dr. Warren? How many samples of adulterated liquors did he find among the six hundred which he examined? Mention some of the poisons used in adulterating the liquors. What did the manager of the St. Louis Wholesale Liquor Association say about adulterations? Give two reasons why alcoholic drinks are adulterated. What must the drugs do for the drink? Which is the more dangerous, pure alcoholic drinks or adulterated drinks? Why? Give the case of the two men who drank whisky. What did Dr. Cox discover about the whisky? Tell the story of the two fishermen. Which would be safer, to get a liquor dealer's recipe book and mix our own drinks, or to buy drinks as they are sold? Why? What did Mr. Redding discover about port wine? How can we tell whether an alcoholic drink is adulterated or not? Does it often happen that those who use adulterated drinks die suddenly? How do we know that their lives are shortened by their drinking? (The answer is in the eleventh chapter of *Town and City*.) What is the great objection to patent medicines? In which medicines is there a large per cent of alcohol? What does the United States law about patent medicines demand? How can we tell whether a bottle contains poisons or not?

Chapter XVIII

What men were used as a sort of laboratory for food experiments? From what department of the army service did they go? In what town were the tests made? What special treatment did the men receive? Did they eat more or less than other men? What was the result? What did the tests prove about the need a man has for meat? Who should eat most and who should eat least? Mention two things that food does for the body. Mention the five food substances. Whence do

plants get their nourishment? Whence do animals get theirs? Which kind of food contains the most proteid? What two kinds of food does the word "carbohydrate" include? Is carbohydrate most abundant in the food we get from plants or in that which we get from animals? Which food substance does the body use in building up tissue? Which does it use as fuel for energy? Which for warmth? When too much carbohydrate is eaten what becomes of the surplus? When too much proteid is eaten what becomes of the surplus? When does a person need the most proteid and the most carbohydrate? If we do not eat meat, what articles should we use instead, to supply ourselves with proteid? Plan some meals where the proteid is supplied by something else than meat. (You will need to study the table for this.) Why are creamed potatoes more nourishing than potatoes boiled in water? Why is macaroni and cheese a most nourishing dish? Why would it never do to take our nourishment in condensed tablets?

Chapter XIX

Where did Dr. Cannon conduct his experiments on cats? Why were cats chosen? Why was bismuth mixed with the cats food? What did Dr. Cannon wish to learn about the stomach? Why did he use the X-rays? Describe the waves of motion. Describe the changing shape of the stomach. How soon after eating did the food begin to leave the stomach? What is the name of the muscle that guards the outlet? Describe the uneven action of the pylorus after the cat swallowed the tablet of bismuth and starch paste. What did this experiment prove? Why is it a disadvantage to have food detained too long in the stomach? What discovery did Dr. Cannon make in connection with the cat that lost its temper? What emotions have the power to stop all action of the stomach? What effect does a happy mind have on the work which the stomach does?

Chapter XX

What is food in the stomach called when it is soft enough to pass through the pylorus? How long is the small intestine? How thin is chyme when it passes through the pylorus? What makes it grow thinner yet in the food tube? What is chyme called after it enters the food tube? Describe the action of the food tube as it was studied by means of the X-ray. How rapidly did the peristaltic action take place? How fast did the chyle move through the tube? Would rapid movement of the chyle be an advantage or a disadvantage to the body? Where are the villi? What are they for? Why is chyle squeezed up against them so often? If food is not absorbed by the villi, what becomes of it? From the time food is cooked and eaten until its journey is ended, what is all the preparation for? How many villi are there? What is each one like? What do they do? What is the great object of peristaltic action? What happens when the food is not thoroughly prepared for the villi? Where, then, does food meet its final test? What happens to food if it is kept too long either in the pantry or in the food tube? Give some reasons why a person may be only half nourished although he swallows a good deal of food. Describe the progress of a mouthful of food from the time it is put in the mouth until it reaches the villi.

Chapter XXI

Tell what you can about the effect of tempting a dog with meat? How many sets of salivary glands are there? What two things make saliva flow? Have you tested yourself in both these directions? Why does a sensible man with a weak stomach eat dry toast rather than delicate custard? How does saliva affect starch? What does it do to certain kinds of sugar that are hard to digest? Give two reasons why we chew food thoroughly. (First, to soften it; second, to mix it with saliva, which will change it and prepare it for its next course of treatment.) Why

should babies, and older persons also, take their milk in sips, and not in a pouring stream? What can gastric juice do to raw meat? Which needs the most chewing, raw or cooked meat? Describe the gastric glands. Describe the tests with dogs which proved certain points about the flow of gastric juice. What should always be done after tempting a dog with food? Under what circumstances does gastric juice flow fastest and longest? What can you say about the advantages of hunger? Give two reasons for cooking food. What does cooking do to starch cells? What foods should we eat for the sake of vitamines?

Chapter XXII

What is the name of the largest gland of the body? Where does it lie? How much does it weigh? What does the liver do with the liquid food which it receives from the villi? What is glycogen for? What does the liver do with venous blood? What is bile good for? Mention the three occupations of the liver. What does a doctor sometimes advise a man to do when he has liver trouble? Why is a piece of raw liver so bloody? Why is alcohol especially harmful to the liver? How large does a liver sometimes become through the use of alcohol? What objection is there to fat in the liver? Where are the kidneys? What do they look like? What do they do? If they are out of order and cannot clear the blood of its proteid waste, what diseases may follow? What do insurance companies think of a man whose kidneys are out of order? What do scientists say about the effect of alcohol on the kidneys? Why is beer especially harmful? (Because it is a weak drink, generally taken in large quantities.)

Chapter XXIII

Describe a fashion-plate woman. What harm is she doing to her liver? Why will her complexion probably suffer? What does lacing do

to the stomach? How does lacing affect the food tube? What is the diaphragm? Describe its location. What work does it do? What organs lie below it? What is above it? What tubes pass through the diaphragm? What work is done by the organs above the diaphragm? What is done by the organs below the diaphragm? In what way is the diaphragm connected with breathing? When you contract your diaphragm, is air drawn in or expelled from the lungs? When the diaphragm contracts what does it do to the organs below it? What organs are helped by the exercise which this regular action of the diaphragm gives them? How does lacing interfere with the work of the diaphragm? What effect does lacing have on the lungs and on the heart? For best health, how loose should the clothes be? Why should weights be kept from dragging down on the abdominal wall?

Chapter XXIV

Where and what is Okushiri? What was the occupation of the inhabitants? What was their condition in 1884? How did they solace themselves? What kind of man was the governor and what did he advise his people to do? Tell what you can about the formal statement which some of them drew up. What was the object of this statement? Who were asked to sign it? When was this done? Mention some of the things to which they pledged themselves. How were the fines to be spent? How long was the contract to be in force? How many signed the contract? At the end of the five years what was the condition of the Okushiri islanders? How were they then regarded by neighboring people? What did they then decide to do for the next five years? If you care to do so, find out the price of one glass of beer, and also the price of various articles of food, and decide for yourself how much a man can buy during one year with what he might have spent for three glasses of beer a day during that year.

CHAPTER XXV

Tell how Paris began to attack its liquor problem. When did France prohibit the manufacture and sale of absinth? What orders were issued by Russia in 1914? How many people did these orders affect? What did Professor Sepälä say about the results of this action? What did England do to reduce liquor consumption? What is the liquor law in Japan? What orders did the United States government issue regarding its training camps? Why do you think the discussion lasted so long in the House of Representatives? What was the result of that discussion?

Name some of the other prohibition victories in the United States. What has Canada done about prohibition? Give the three great arguments against alcohol. Why are taxes high in countries that use alcohol? What sends many people to the poorhouse, the jail, the insane asylum, and the orphans' home? Give Mr. Boies's statement about the cost of drunkenness in the United States. What is London's annual expense for drunken paupers? In what way does every honest man help support those who are criminals and worthless?

CHAPTER XXVI

What were scientists trying to learn about the heat of the body in 1775? Describe the way they tested their bodies in heated rooms. How hot was the air? What happened to beefsteak, eggs, water, and watch chains that were in the same room? How did the men feel? What saved them from being cooked? When were the sweat glands most active? How many sweat glands is a human being supposed to have? Describe the epidermis. Describe the dermis and tell what is in it. Describe perspiration. How does it keep the skin cool? What things are mixed with perspiration upon an unwashed skin? From what part does new skin grow to cover a wound? When a wound is too large

to be covered by skin that grows from the edges, what is done to supply a man with new skin? When is perspiration called "insensible"? What is sensible perspiration? When a man is heated, what happens to the capillaries? When a heated man sits in a draft what do the capillaries do? Where is the blood sent from these capillaries? What is generally the first symptom of a cold? Describe the behavior of white corpuscles at such times. When white corpuscles are inactive what about the microbes? Why is a man who has a cold more liable to take other diseases? If you feel a cold coming on, what should you do to check it? In what ways may we take cold by chilling the blood?

Chapter XXVII

What can you say about the heat of the body in different countries? What is the normal temperature of a human being? Which animals are warm-blooded? What is the difference between warm-blooded and cold-blooded creatures? Why does a room grow warm when several people are present? Why do we wear more clothes at one time than at another? How does exercise help keep the body warm? What connection is there between food and the power of the body to heat itself by exercise? When much exercise is taken what stored-up fuel is drawn upon? What may a fat man do to change his appearance? How can you explain the fact that hard exercise has little effect on the inside temperature of the body? Since the body can cool itself when it is too warm, what is the danger? Give three rules for preventing the escape of heat when the body needs it. Are we warmed by keeping the cold out, or by keeping the heat of the body in? Why do we choose flannel for winter and cotton for summer wear? Give four rules that help the body to adjust itself to heat and cold. What is the great work of hygiene?

GLOSSARY

KEY TO PRONUNCIATION

a	as in fāte, senāte, făt, ärm, ạll, åsk, whạt, câre.				
e	" mēte, ēvent, mĕt, hẽr, thêre, obe̱y.				
ee	" fe̅e̅t.				
i	" īce, ĭdea, ĭt, sĩr, machïne.				
o	" ōld, ōbey, nŏt, mọ̈ve, wọlf, sȯn, hôrse, wõrk.				
oo	" fo̅o̅d, fo͝ot.				
u	" ūse, ūnite, ŭp, fûr, rụle, pụ̈ll.				
y	" flȳ, mȳself, babỹ, mỹrrh.				
au	" author.				
aw	" saw.	ew	as in new.	oi	as in boil.
oy	" boy.	ou	" out.	ow	" cow.
c	(unmarked) as in call;	ç	" mice.		
ch	(unmarked) " child;	çh	" chaise;	ch (= k)	as in school.
g	(unmarked) " go;	ġ (= j)	" cage.		
ng	as in ring.	n̲ (= ng)	" ink.	ph (= f)	as in phantom.
s̝ (= z)	" is.	si (= sh)	" tension;	s̝i (= zh)	" vision.
th	(unmarked) as in thin;	th	" then.	ti (= sh)	" motion.
x	(unmarked) " vex;	x̝ (= gz)	" exact.		

Obscure sounds: a̤, e̤, i̤, etc. Silent letters are italicized.

ăb′sĭnth, an alcoholic liquor.

ȧ dŭl′tĕr āt*e*, to corrupt by mixing with inferior materials.

ăd′ē noid, a growth in the nose.

ăl ĭ mĕn′tȧ rȳ canal, the food canal.

ā ôr′tȧ, the great artery from the heart.

är′chĭ tĕct, one who plans buildings.

är′tẽr ȳ, one of the vessels or tubes which carry the blood from the heart.

ăt′rō phȳ, wasting away from lack of nourishment.

bĕr′ĭ bĕr′ĭ, a disease due to defective diet.

bĕv′ẽr āġ*e*, drink of any kind.

bī′çĕps, a muscle having two heads; the term is applied to a muscle in the arm.

căp′ĭl lă rȳ, one of the fine vessels or tubes connecting the arteries and veins.

cär′bŏn dī ŏx′ĭde, a gas; dissolved in water becomes carbonic acid.

cär′tĭ lȧġe, an elastic tissue; gristle.

chȳle, the contents of the small intestine.

chȳme, food in the form in which it passes out of the stomach.

çĩr cū lā′tion, moving in a circle or circuit.

çĩr′cū lȧ tō rȳ, pertaining to circulation, as of the blood.

cō′cȧ ĭne, a drug which produces local insensibility.

cŏc′çȳx, part of the backbone.

cŏn trăc′tion, a shrinking; shortening.

côr′pŭs cle, a minute particle; blood corpuscles, — the blood disks or cells.

crude, raw, not fitted for use by any artificial process.

cûr′vȧ tūre, a bend; a curve.

dẽr′mĭs, the second layer or true skin.

dī′ȧ phrăgm, a muscle separating the chest from the abdomen.

ĕp ĭ dẽr′mĭs, the outer layer of skin.

ē văp′ō rā′tion, conversion of a fluid into vapor.

ġĕl′ȧ tĭn, a substance made by boiling bones and other animal tissues. It is used in glue and as a jelly for food.

glŏb′ūle, a little globe.

glȳ′cō ġĕn, a substance found in many animal tissues, and especially abundant in the liver.

ġȳm′năst, one skilled in athletic exercises.

hī′bẽr nāte, to pass the winter in a torpid state, as some animals do.

ĭn grē′dĭ ent, one of the elements of a combination, as a drink, or medicine.

lăt′ẽr al, sidewise.

lēague, persons united for some particular purpose.

lĭg′ȧ ment, the tissue that connects bones.

lȳmph, a colorless fluid in animal bodies.

lȳm phăt′ĭc, a vessel which conveys lymph.

mĕm′brāne, a thin, soft tissue in the form of a sheet or layer covering parts of the body.
mī′crō scōpe, an instrument for examining objects too small for the naked eye.
mŭs′cle, a tissue in animal bodies whose contraction causes motion.
mŭs′cū lar, having well-developed muscles; strong.

nôr′mal, regular; natural.
nū trĭ′tion, that which nourishes or repairs the waste in tissues.

ō′pĭ ŭm, the juice of the poppy; a drug.
ôr găn′ĭc, pertaining to objects that have organs.
Ō-ku-shĭ-rĭ, an island on the coast of Japan.
ŏx′y̆ ġĕn, the element of the air that supports life.

păr′ȧ ly̅ze, to render helpless.
păt′ent mĕd′ĭ çĭne, a drug, the sale of which is secured by law as the special privilege of the proprietor.
pĕr ĭ stăl′tĭc, contracting in successive circles.
pĭg′ment, coloring matter.
plăs′mȧ, the liquid part of the blood.
plē bē′ian, pertaining to the common people.
prō′tē ĭd, food stuffs which form tissues are proteids.
pŭlse, the beating of the heart as felt in the arteries.
py̆ lō′rŭs, the opening through which the contents of the stomach pass into the intestine.

rĕġ ĭ mĕn′tals, military clothing.
rhy̆th′mĭc, sounds occurring regularly, as accents in poetry or music.
rĭck′ĕts, a disease of children, in which they are weak in the joints.
rō′tāte, to revolve; to move round a center.

sä′kĕ, a Japanese fermented liquor made from rice.
săl ĭ çy̆l′ĭc, the name of an acid.
săl′ĭ vȧ ry̆, pertaining to saliva.
săr cō lĕm′mȧ, the covering of separate muscle fibers.
sphy̆g′mō grăph, an instrument used in determining the strength of the heart beat.
stĭm′ū lant, that which excites; a medicinal agent for increasing vital activity.
sy̆m mĕt′rĭc al, well proportioned in its parts.

sy̆r′ĭnġe, an instrument like a pump, drawing in and ejecting liquids.

tăd′pōle, the young of a frog.

tĕn′dŏn, a bundle of fibers which joins a muscle to a bone.

tĕnse′ly̆, tightly; rigidly.

trō′phy̆, a memorial of victory.

vein, a vessel which receives blood from the capillaries and returns it to the heart.

vī′tạ mïne, a vital element of our food.

vĭl′lŭs (plural, villi), a minute elevation on the lining of the small intestine.

FOREIGN NAMES

De bŏve′

Făi sâns′

*H*ō tĕl de Vĭlle′

*H*ō tĕl Dĭeû′

Hĕ le′nĭ us Sepälä (sĕ pê′lĕ)

Hĕl sĭng fŏrs′

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